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Next Generation Access in a Rural Community Context:

An Innovation Analysis

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Abstract

This thesis explores how to resolve the digital divide in Wales. This is important because access to advanced broadband is considered an essential requirement, particularly post-COVID19. UK Government is advocating next generation access (NGA) to capitalise on Industry 4.0. However, the financial costs and complexities of connecting the final few rural areas is a persisting problem area. Hence, this thesis explores new innovative approaches to provide NGA (product) to a final few (market).

Studies revealed superfast broadband in remote rural communities has four-fold human, social, environmental and financial capital benefits. Analysis resulted in a new conceptual framework which combines neo-endogenous theories alongside a four-fold capital model to characterise the complex ecosystem.

Previous literature focused on either supply or demand, but few studies had investigated both together at the local level. Human & social capital were identified as critical success factors in community-led initiatives, thus providing a theoretical underpinning for this thesis.

This study employed a novel mutual business approach utilising the Hybrid Value System (HVS) as an ecosystem connecting the core assets of several stakeholders. Furthermore, the World Bank Social Capital Assessment Tool was modified to investigate social capital fertility to enhance investment. Henceforth, a qualitative multi-method and in-depth intrinsic case study was used to explore the ecosystem.

The contribution to knowledge is how to engage multi-stakeholder and multi-capital analysis to resolve the problem area. The results identified human capital productivity, social capital collective action, and shared financial capital are required at the local level to reach the final few.

The mutual business paradigm challenges all stakeholders to value non-financial capital alongside financial capital for problem area resolution. This thesis concludes that HVS methodology coupled with complex ecosystem-network visualisation techniques, provide academics, management and government policy makers with practical tools to value four-fold capital resources and bridge the digital divide.

Declaration and Statements

DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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STATEMENT 1

This thesis is the result of my own investigations, except where otherwise stated. Where correction services have been used, the extent and nature of the correction is clearly marked in a footnote(s).

Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

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Abbreviations

ADSL	Asymmetric Digital Subscriber Line
BDUK	Building Digital United Kingdom (formerly Broadband Delivery UK)
CCF	Community Capital Framework
CFP	Openreach Community Fibre Partnerships
CSF	Critical Success Factor
CSO	Citizen Service Organisations
DCMS	Department of Digital, Culture, Media and Sports
DEFRA	Department for Environment, Food and Rural Affairs
DIIF	Digital Infrastructure Investment Fund
DIY	Do-it-Yourself
DPS	Dynamic Procurement System
DSL	Digital Subscriber Line
DSLAM	Digital subscriber line access multiplexer
EC	Environmental capital
EO	Engagement Officers
FTTC	Fibre to the Cabinet
FTTH	Fibre to the Home
FTTP	Fibre to the Premise
FC	Financial capital
Gbps	Gigabit per second
GPON	Gigabit Passive Optical Network
HC	Human capital
HVC	Hybrid Value Chain
HVS	Hybrid Value System
LDC	Local Digital Champion

IM	Innovation Management
ISP	Internet Service Provider
Mbps	Megabits per second
MBs	Microbusinesses
NED	Neo-endogenous approach
NGA	Next Generation Access (includes full fibre and 5G technologies)
OFCOM	Office of Communications
OI	Open innovation
PCC	Pembrokeshire County Council
PON	Passive Optical Network
RSCAT	Rural Social Capital Assessment Tool
RCUK	Research Council UK
SFC	Shared financial capital
SC	Social capital
SCAT	Social Capital Assessment Tool (World Bank)
SV-A	Splits-Ville A
SV-B	Splits-Ville B
SFBB	Superfast Broadband
SBCD	Swansea Bay City Deal
UFBB	Ultrafast Broadband
VDSL	Very high bit rate Digital Subscriber Line
WRDT	Wales Rural Digital Taskforce (referred to as The Taskforce)
WA	Welsh Assembly (*name changed to Senedd/Welsh Parliament in May 2020. Nonetheless, the literature reviewed referred to Welsh Assembly)
WG	Welsh Government
WEF	World Economic Forum

Chapter One: Introduction

1.1 Purpose

The purpose of this research is to investigate how a local community approach may help to resolve the persisting digital divide by overcoming supply and demand challenges in rural areas of the United Kingdom (UK). The definition of digital divide constructed for this thesis is the inequality or lack of access to advanced broadband as experienced by rural communities. This is considered important because digital infrastructure can be regarded as a fourth utility, alongside electricity, gas and water, particularly post-COVID19. The term digital divide refers to *"the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities"* (OECD, 2006).

Previous studies showed superfast broadband (SFBB) enabled rural communities and microbusinesses (MBs) to receive four-fold human, social, environmental and financial capital benefits (Phippen & Lacohée, 2016; SQW, 2013), but not every rural area has access (Blank, Graham, & Calvino, 2018; Philip, Cottrill, Farrington, Williams, & Ashmore, 2017). Moreover, a new and innovative mutual business management approach has emerged to engage human, social, environmental and shared financial capital to resolve supply and demand opportunities and challenges in the final few and hard to reach areas (Roche & Jakub, 2017).

As of May 2019, the rural broadband market has changed to provide the UK with next-generation access (NGA), or full fibre-to-the-premises (FTTP) and fifth generation (5G) mobile communication networks (hereafter referred to as "full fibre & 5G"). These changes are in anticipation of the fourth industrial revolution, or Industry 4.0, where smart technologies will be used to connect everything to the Internet and unleash a new era of innovation opportunities and challenges (European Commission, 2017; NAW, 2018). Thus, the focus of this research is to investigate how local community engagement, in conjunction with this new wave of innovation, might help to overcome the supply and demand challenges and enable rural communities and

MBs to develop the four-fold human, social, environmental and financial capital benefits.

A world-changing event transpired during the data collection time-period between January 2020 – March 2020. The global outbreak of COVID19 and subsequent lockdown of the UK has had profound effects on the critical need for effective rural broadband connectivity (Evans & Evans, 2020, June 5; Williams, 2020, April 22). Correlations will be made in the findings as to the impact this has had on rural communities in Wales (Section 5.8.5).

Purpose statement

Creswell (2014) suggests providing a summarised purpose statement for the reader post-research. Therefore, the purpose of this multi-method exploratory research is to investigate how to resolve NGA supply and demand challenges for rural communities in a "final few" and hard to reach area. The in-depth intrinsic case study in Pembrokeshire, South Wales, investigates new and innovative approaches to resolve this complex multi-stakeholder problem area.

1.2 Research Aim & Objectives (OBJs)

Rural communities and MBs have a demand for improved access to advanced broadband services, but it is not commercially viable for information and communication technology (ICT) suppliers to provide it in the final few and hard to reach areas (DCMS, 2018b; INCA, 2019). Hence, there is a supply and demand challenge to overcome. The aim, therefore, is to enable rural communities and MBs to access and exploit NGA services, particularly in relation to the forthcoming Industry 4.0.

The first, and second objectives, are interlinked and provide the complex of knowledge required to investigate the supply and demand challenges in reaching the final few rural communities. The objectives therefore are:

OBJECTIVE (OBJ) 1 - Rural Broadband – the final few and hard to reach

1A. To evaluate community-led initiatives in providing advanced broadband in the final few and hard to reach communities.

1B. To evaluate the supply in providing advanced broadband in the final few and hard to reach communities.

1C. To evaluate the demand in providing advanced broadband in the final few and hard to reach communities.

OBJ 2: Rural Broadband – drivers, opportunities, barriers & critical success factors

2A. To identify the drivers & opportunities related to Industry 4.0 and NGA.

2B. To analyse the drivers & opportunities related to implementation (supply) and take-up (demand) of NGA in the final few and hard to reach rural communities.

2C. To analyse the barriers to implementation and take-up of NGA in the final few and hard to reach rural communities.

2D. To analyse the critical success factors that contribute to the implementation and take-up of NGA in rural communities.

OBJ 3. Innovation Analysis – new approaches to reach the final few

To identify new and innovative alternatives in ICT supply and demand resolution that can be applied to bridge the digital divide gap in final few and hard to reach rural areas.

1.3 Research Background

The innovation opportunities afforded by the Internet demand increasing broadband speeds and improved access (Hutton & Baker, 2018; Ipsos MORI, 2018). Connection to the global digital economy is considered essential for economic, environmental, productivity and social capital benefits (Section 2.4.6), specifically in rural communities (Castells, 2010; Phippen & Lacohée, 2016). In July 2018, the UK Government announced plans to provide full fibre and 5G to "future proof" the nation

and make it more competitive with other countries (DCMS, 2018b), particularly with the advent of Industry 4.0 (DCMS, 2018, July 23; FTTH, 2019). Industry 4.0 is a term introduced by the German government to describe digitisation of the manufacturing industry (Lasi, Fettke, Kemper, Feld, & Hoffmann, 2014). Industry 4.0 can be described as the proliferation of the Internet of Things (IoT), cloud computing and "smart" manufacturing, or "cyber-physical systems", which will require ubiquitous high-speed broadband services to support the influx of digital productivity and data collection (DCMS, 2018b; FTTH, 2004; Lasi et al., 2014).

Currently, broadband speeds are measured in megabits per second (Mbps), which is the rate of data transfer for uploading and downloading information (Christensson, 2006c; Hutton & Baker, 2018). The nationally recognised lowest acceptable speed for downloading in the UK is "basic broadband", defined as two Mbps (DCMS, 2016a). Recently, the UK Government launched a new Universal Service Obligation (USO) increasing basic broadband to "decent broadband" of 10 Mbps by 2020 (DCMS, 2016b; Ofcom, 2018a). Superfast broadband (SFBB) is defined as 24-30 Mbps, and Ultrafast broadband (UFBB) is defined as 300 Mbps (Hutton & Baker, 2018; Jackson, 2015, December 1). New "full-fibre broadband" service provisions offer one Gigabit (or 1000 Mbps) and above (Christensson, 2013; FTTH, 2004, 2019). Thus, the UK broadband speed differentials can range from two Mbps (or less) in remote rural areas, to over 1000 Mbps (or one Gbps) in mostly urban areas (Philip et al., 2015b).

Ofcom (2018b) reports the current state of play for coverage of SFBB is 94%, UFBB is 50%, full fibre (1 Gbps) at 6%, but 2% cannot get decent broadband (p. 5). Previous studies (Philip, Cottrill, & Farrington, 2015a) revealed access of population to SFBB ranges from a *"high of 86.43% of postcodes in urban England to a low of 1.18% of postcodes in deep rural Wales"* (p. 390). Ofcom (2018b) acknowledges the gap between rural access for decent broadband is 12% compared to urban 1% (p. 4). In 2018, the Future Telecoms Infrastructure Review (FTIR) identified approximately 10% of rural and remote UK premises would be unlikely to receive full-fibre by 2033 (DCMS, 2018b). Examples to illustrate the variances in broadband speeds and use are shown in the following (Table 1.1):

Table 1.1 Examples of broadband speeds and use variations.

(Hutton & Baker, 2018; OECD, 2018)

Average download rate	Description of service	UK definitions
Broadband		
Less than 0.5 Mbps	Web browsing, email, audio, mobile-quality video streaming, voice & Standard-Definition (SD) video calling.	*Under USO*
0.5 – 2.0 Mbps	SD video streaming, High-Definition (HD) video calling.	*Basic*
10.0 - 20.0 Mbps	Ultra-High-Definition (UHD) video streaming.	*Decent*
Over 20.0 Mbps	High frame rate UHD video streaming, augmented reality, advanced telemedicine (e.g. Industry 4.0 technologies).	*SFBB & UFBB*
10 Mbps	Downloading a UHD movie – takes 5 hours.	*Decent*
1 Gbps	Downloading a UHD move – takes 5 minutes.	*Gigabit*
Mobile		
4G capability	10-20 Mbps – streaming 1 Netflix movie.	*Decent*
5G capability	20 Gbps – streaming 450 films at the same time – downloading in seconds, not minutes.	*Gigabit*

**Examples combined from OECD (2018) Bridging the digital divide report (p. 13), House of Commons (2018) Superfast broadband in the UK library briefing (p. 5), Digital Trends (2018) & BBC Click (2018).*

In addition, Ofcom (2017) confirmed access to decent broadband is a concern for small businesses. Entrepreneurs are vital to the growth and development of an economy and should be supported for the benefit of individuals, communities and the nation (Schumpeter, 1959). Entrepreneurial activity will be required to engage Industry 4.0 innovation opportunities, particularly for rural communities (see Section 2.1).

While the majority of research in small businesses is undertaken under the heading "Small & Medium Enterprises (SMEs)", in the context of the final few and hard to reach rural areas that are part of this study, the population density is so low that the majority of entrepreneurial activity is undertaken by microbusinesses (MBs) and sole traders (Rhodes, 2018; Wilson, Atterton, Hart, Spencer, & Thomson, 2018). While Microbusinesses (MBs) are defined as having less than 10 employees, the majority of enterprises in that size band in the UK have only one or two employees (Rhodes, 2018). The challenges for NGA faced by MBs in deep rural locations (the final few & hard to reach rural communities will be defined in Section 2.2) are greater than might be expected for enterprises in the SME size bracket, from 10 to 249 employees. It is

important to recognise that the larger SME bands are not only rarely found in these deep rural geographies, but that they also represent greater demand for services, higher turnover and potential for profit for network infrastructure companies to provide services to and therefore they do not play such a key part in the chronic supply and demand challenges that this research aims to address.

The academic literature around MBs is, however, often conflated for all size brackets of SMEs. This is a recognised issue with research and often due to issues of access to research opportunities (Gherhes, Williams, Vorley, & Vasconcelos, 2016). In the absence of specific literature relating to MBs and NGA, SME literature has been used to inform this study.

This research is focused on reaching the final few rural communities, hence MBs, as opposed to SMEs, will be included in this study. More specifically, deep rural MB research was involved as a precursor to this study which will be explained in (Sections 2.3.6.3 & 3.4). Nevertheless, to summarise this section regarding speed and access, NGA will be used to describe improved connectivity over and above 10 Mbps.

Furthermore, the Research Council UK (RCUK) for the Digital Economy invested over £138 million to explore the transformational impact of digital technologies on communities (Philip, Townsend, Roberts, & Beel, 2015c). The *"dot.Rural"* Digital Economy Hub at the University of Aberdeen was commissioned to investigate the rural digital economy. Funding was provided between 2009-2015 by the Engineering and Physical Science Research Council (EPSRC) stating rural areas have untapped economic potential (RCUK, 2015). The UK Research and Innovation (UKRI) Rural Digital Economy Hub states by working digitally in flexible and innovative ways "*rural businesses and communities can build on their social, economic and environmental capital to generate new wealth, employment and social opportunities"* and potentially release upwards of £340 million per annum into the UK economy (UKRI, 2015, p. 1).

Debates over rural broadband access, speed, and take-up continue, but numerous efforts are being made to bridge the urban-rural digital divide (DCMS, 2016a; Hutton & Baker, 2018; Openreach, 2019b). Previous efforts included government voucher schemes, community partnership collaborations and market test pilots to trial various

financial, operational and technical solutions to bridge the gap (DCMS, 2016b; Hutton & Baker, 2018; Openreach, 2019b). In May 2019, the UK Government announced the Rural Gigabit Connectivity (RGC) programme allocating £200 million to fund an "outside-in" approach to provide full-fibre connectivity to remote rural areas (DCMS, 2019c). The initial strategy is to identify and connect health-care facilities and schools, or *anchor institutions*, in rural areas to act as a "hub" to eventually provide access for the surrounding area (Ashar, 2019, May 22; OECD, 2018). This new initiative is in the preliminary stages of deployment but does not include rural areas without health care facilities or schools (INCA, 2019).

1.4 Research Context

Research examining the impact of SFBB in rural communities reveals human, social, environmental and financial capital benefits (Ashmore, Farrington, & Skerratt, 2017; OECD, 2018; SERIO, 2015; SQW, 2013; Wallace, Vincent, Luguzan, Townsend, & Beel, 2017). Thus, advanced broadband is required for rural communities and microbusinesses (MBs) to develop the four-fold capital benefits (Bowen & Morris, 2019; Leong, Pan, Newell, & Cui, 2016; Morris, Henley, & Dowell, 2017; Phippen & Lacohée, 2016).

According to Ofcom (2017), England has superior access to broadband than Northern Ireland, Scotland and Wales. In Wales, 5% of premises cannot get decent broadband (p. 3). Numerous rural SFBB studies have focused on England and Scotland (Philip et al., 2017; Townsend, Wallace, Smart, & Norman, 2016; Wallace et al., 2017), but not as many in Wales (Morris et al., 2017; Thomas, Miller, & Simmons, 2015). A recent Welsh rural community-built fibre-to-the-home (FTTH) broadband success story has drawn attention to the region when Michaelston-y-Fedw "MyFi" scheme was nominated for 2018 European Broadband Awards (Jackson, 2018, November 8). Hence, the geographical context for this research is Wales.

1.5 Research Problem

Recent rural community-led initiatives have achieved full-fibre networks (one Gbps), but the uptake of faster Internet speeds for rural areas remains questionable which can affect commercial viability and investment (Ashmore et al., 2017; DCMS, 2016a; Phippen & Lacohée, 2016).

Recent observations at the Regional Studies Association (RSA) conference in Cardiff, South Wales (RSA, 2019, May 22) and at the Rural Gigabit Connectivity Event (INCA, 2019, May 24) in Conwy, North Wales, provided additional insights into the challenges facing rural broadband connectivity. According to Spectrum Internet, an alternative network provider (or *Altnet)*, investors want to invest, but take-up in Wales does not make it a viable option. This statement seemed contrary to Lee Waters, Assembly Member (AM) and Deputy Minister for Economy & Transport, who stated the take-up rates in Wales are higher than the UK average. Discrepancies in take-up rates exist (Winckler, 2009), and in this case, clarification of SFBB take-up rates versus full-fibre take-up rates would need to be clarified. Lee Waters advised out of the £67 million Welsh Government funding offered, only £20 million was procured by British Telecommunications (BT) as the sole contract bidder. Mr. Waters admitted that some of this is due to European Union (EU) funding restrictions coming to an end by 2021, but there were no other bidders for this funding. At the Rural Gigabit Connectivity Event in North Wales (INCA, 2019, May 24), another Altnet, Broadway Partners, stated financial investment is available, but more coordination is required to clarify business models, not only for investors, but for suppliers and take-up rates in rural communities. Vivien Collins from the Welsh Government stated "multiple solutions" are required because no one solution fits all.

Alongside the Industry 4.0 fibre-to-the-premise (FTTP) agenda, sits the 5G mobile network implementation. 5G is not simply a faster mobile speed, but an entirely new mobile broadband network architecture. 5G radio waves are fast with higher frequencies and shorter waves but cannot travel long distances (e.g. 300 metres versus 10 kilometres with 4G), or travel easily through buildings or walls, and are affected by adverse weather conditions (Digital Trends, 2018). Numerous masts are required in close proximity to implement 5G technology, which can be deployed to provide a "relay" service from one mast to another (UK5G, 2018). 5G is being heralded to provide autonomous vehicles, telehealth innovations and so forth, but it requires considerable coordination, investment and permissions to implement the new system (BBC Click, 2018; DCMS, 2018a; Jackson, 2019, June 17). Recent observations at the DCMS UK5G Rural Connected Communities (RCC) project workshop in Newport, South Wales (DCMS, 2019, June 19), explained the aim is to build the business case for rural mobile connectivity. Numerous supply and demand barriers, challenges and

opportunities were highlighted in the workshop and will be discussed in greater detail in the research context (Chapter Two).

At present, the market is changing. Broadband Delivery UK (BDUK), which is the UK Government entity tasked with rolling-out superfast broadband, recently changed its name in May 2019 to "Building Digital UK" (BDUK) to reflect the government's changes towards implementing Industry 4.0. The Rural Gigabit Connectivity (RGC) programme is a result of this step-change, and the growing numbers of Altnets will aid the proliferation of "full fibre & 5G" services over the next decade, but the market is complex.

These complexities are currently challenging NGA supply and demand provision in rural areas (Salemink, Strijker, & Bosworth, 2017b). At present, telecommunication providers cannot cater to every individual need, and the government cannot cover every short-fall (Gerli, Wainwright, & Whalley, 2017; Salemink et al., 2017b; Wallace, Vincent, Luguzan, & Talbot, 2015). Previous frustrations with commercial suppliers and local government have forced rural communities to act and develop community-led broadband initiatives, but it is a challenging endeavour, and not all are successful (DCMS, 2016a; Gerli & Whalley, 2018). Nevertheless, recent studies have revealed critical success factors (CSFs) that indicate the value of human, social and other forms of "capital" which contribute to the success of community-led initiatives and will be examined further in this thesis (Section 3.5 & 3.6).

1.6 Research Gaps

Studies attempting to resolve the final few and hard to reach rural areas recognise it is not a "one size fits all" solution (DCMS, 2016a; Nandi et al., 2016; Wallace et al., 2015; Williams, Philip, Farrington, & Fairhurst, 2016). Current research suggests resolving these challenges through community engagement due to local differences that can contribute to the success or failure of investment (Gerli & Whalley, 2018; Salemink & Strijker, 2018; Salemink et al., 2017b). Recent rural broadband literature calls for more collaborative efforts by combining supply and demand stakeholders into a community-led initiative (Halseth, Markey, & Ryser, 2019; Leong et al., 2016; Philip et al., 2015a; Salemink et al., 2017b). The value of human & social capital has been

identified as critical success factors and will be incorporated into the thesis for further exploration (Hallstrom, Heinrich, & Pearson, 2017; Wallace et al., 2015).

Managing innovation is difficult, particularly within complex multi-stakeholder ecosystems (Bessant, 2015; Tidd & Bessant, 2009). Innovation management studies, as a result of ICT innovation, reveals open innovation, co-creation, collaboration and multi-stakeholder engagement is compulsory for 21st-century business (Chesbrough, 2017; Jones, Cope, & Kintz, 2016). Appropriability challenges, or who benefits financially and non-financially from innovation collaboration, remains to be reconciled (Baldwin & Von Hippel, 2011; Chesbrough, 2017; Teece, 2006). Moreover, new approaches and methods are required to manage and measure the innovation process (Jones et al., 2016; Roche & Jakub, 2017; Schuurman, 2015; Teece, 2010).

1.7 Research Questions (RQs)

Therefore, the RQs to address are:

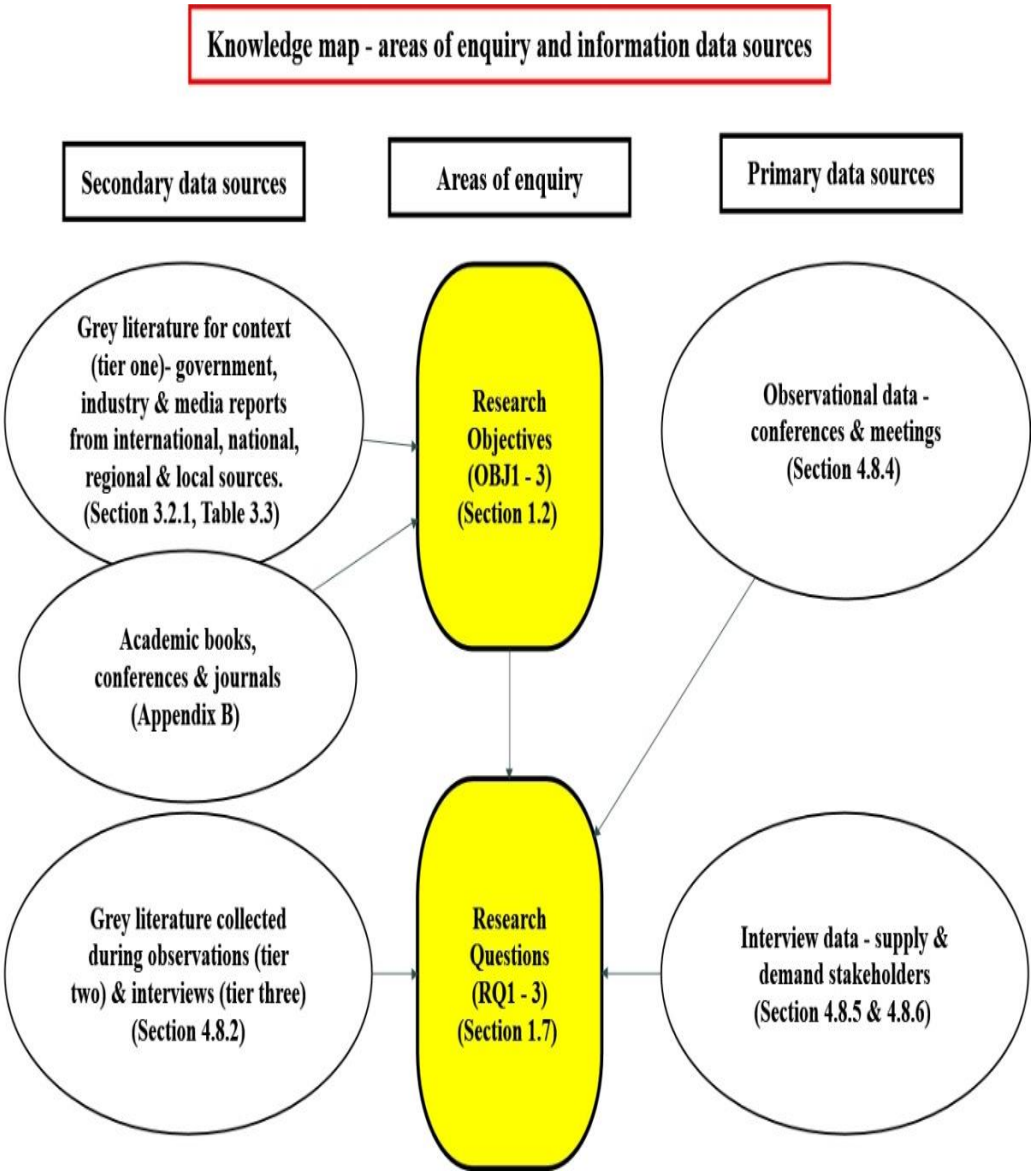
RQ1. What capital resources, financial & non-financial, are required to support infrastructure to enable NGA to be viable for rural communities and microbusinesses to experience the four-fold capital benefits?

RQ2. How can local rural community engagement, within multi-stakeholder ecosystems, help to resolve complex NGA supply and demand challenges?

RQ3. What new and innovative approaches can be utilised to manage and measure this process?

The following knowledge map summarises the areas of enquiry to answer the research aim, OBJs and RQs (Figure 1.1).

Figure 1.1 Knowledge Map - areas of enquiry and data



In summary, the secondary data sources are used to answer the research OBJs which in turn refines and confirms the RQs. Subsequently, the primary data sources are used to answer the refined RQs relevant to resolving the digital divide challenge.

1.8 Research Boundaries

The 2018 UK Government future of telecommunication policy changes were tracked up to the Rural Gigabit Connectivity (RGC) programme launch in June 2019 (DCMS, 2019c). Partial primary data collection from conferences in May-June 2019 were used to update the context in (Chapter Two), but detailed observations are analysed in

(Chapter Five). Conferences attended were the Regional Studies Association (RSA) Wales branch conference on *"Digital technologies, productivity gains and regional resilience: An SME focus"* (RSA, 2019, May 22). The Independent Networks Cooperative Association (INCA) *"Rural gigabit future: Rural Wales"* conference in Conwy, North Wales (INCA, 2019, May 24). The UK5G *"DCMS rural connected communities project workshop"* in Newport, South Wales (DCMS, 2019, June 19). As explained (Section 1.3) the RGC programme is an "outside-in" strategy to connect remote rural communities by providing funding to health centres and schools (anchor institutions). The idea is to provide funding to these anchor institutions first, and then connect the surrounding areas from the "hub". Nevertheless, remote rural areas not in proximity to the hub catchment areas are not included in the strategy.

Additional primary data collection for the rollout of these policy changes began in September 2019 – March 2020 following observations at the Wales Rural Digital Taskforce (hereafter referred to as the Taskforce) at the Welsh Government. This researcher was invited to attend the Taskforce, which constitutes the engagement of Welsh Government officials responsible for the rural gigabit roll-out including 5G. The Taskforce includes local authority officials who report on regional strategies and challenges in providing "full fibre & 5G" to their constituencies. Governmental changes can happen rapidly as one party is elected over another (e.g. a UK general election was scheduled for December 2019), thus the need to establish a base line for this inquiry is required. Henceforth, the base line is drawn from the launch of the RGC programme (June 2019), and the results of the Taskforce (September 2019-March 2020) will be included in the findings (Chapter Five).

To conclude, this thesis is focusing on the areas not reached by the current rural gigabit rollout, namely rural communities who are outside of the "hub" catchment areas. The primary focus of this research is not necessarily policy, although it clearly affects infrastructure decision-making and funding implications. This thesis inquiry is a business management focus on how to get a "product" to a final few and hard to reach "market". Hence, the boundaries and scope of this investigation are within these parameters.

1.9 Structure of Thesis

Chapter One outlines the purpose, introduction and background of this research (Section 1). Chapter Two explains the research context within Wales, definition of rural communities and the capitals therein, and the selection of Pembrokeshire as a rural final few area to conduct the in-depth case study (Section 2). Chapter Three details the academic field, the rural broadband and innovation management literature review and resultant neo-endogenous (NED) supply and demand conceptual framework to conduct the research (Section 3). Chapter Four explains the case study methodology and pragmatic philosophy selected for the inquiry (Section 4). Chapter Five produces the multi-method nation-level contextual findings (Section 5). Chapter Six presents the local-level thematic network analysis detailing the four-fold capitals identified as critical success factors (CSFs) for reaching the final few (Section 6). Chapter Seven discusses the expected and unexpected findings, the application and value of the research through four potential intervention areas, a summary of the revised conceptual framework and how the gaps in the literature were fulfilled to answer the RQs (Section 7). Chapter Eight summarises the conclusions, answers to the RQs, details the new practical and theoretical contributions to knowledge, and the limitations and future research recommendations (Section 8). The appendices and references conclude the study.

Chapter Two: Research Context

The recent 2018-2019 changes in UK Government policy with "full fibre & 5G" implementation for Industry 4.0 and the recent market changes with the Rural Gigabit Connectivity (RGC) programme is re-shaping the rural supply and demand opportunities and challenges. Prior to reviewing the academic literature, it is notable to understand the current state of play regarding the various rural stakeholders and the ecosystem required to engage collaboration for NGA.

Wales was identified in the introduction (Section 1.3) as a final few and hard to reach rural area for further investigation. This chapter describes the research context and the definitions required to scope this thesis and introduce terminology on what is meant by "rural" and "community". The overall Welsh context will be discussed, and then focused into a deep rural final few and hard to reach community necessary for this study (Section 2.1). Definitions for what is meant by rural, community, capital and ecosystems in an NGA context are explained (Section 2.2). The rural community stakeholder ecosystem consists of numerous actors and factors that need to be understood to resolve the supply and demand conundrum (Section 2.3). The overall research context will be summarised in (Section 2.4).

2.1 Rural Wales: An example of final few and hard to reach

The population in Wales is estimated at 3,125 200 million people (ONS, 2018). Welsh households in 2016 totalled 1.3 million (Welsh Government, 2016). If 5% of premises do not have decent broadband, this can equate to approximately 70,000 households. According to a Local IT Expert (hereafter referred to as Mr. G), discussed below, is working to resolve the digital divide, and advised that some deep rural Welsh villages can contain 20 houses. If this is the case, then 70,000 homes or 3,500 communities could be without decent broadband.

Early investigations, prior to the primary data collection, involved interviews with two IT experts in Wales. One is Mr. G who consulted for the Welsh Government and lives in a deep rural Welsh community, and the other consults for the Welsh Government SFBB rollout (hereafter referred to as Mr. P). According to the Mr. G, there are three regions in Wales that are harder to reach because of high mountains and deep valleys: Ceredigion, Pembrokeshire & Powys. If the three regions divide the

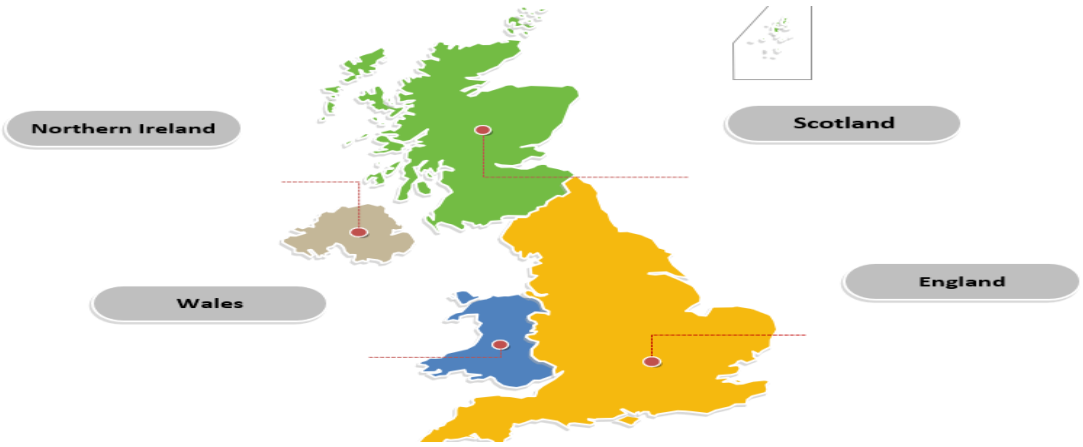
3,500 communities without decent broadband, there are still approximately 1,150 communities per region underserved. This is a rudimentary calculation, but it illustrates that the problem is still on going.

2.1.1 The Welsh economy – Past & present

Wales played a major role during the Industrial Revolution, namely in the early 1700s to the turn of the century, by exporting coal, copper, slate, steel and tin which fuelled the world and helped build their economies (Jones, 1994; Miskell, 2020; Swansea Museum, n.d-b). At one point during the mid-18th century, the port city of Swansea in South Wales was named "Copperopolis" and housed the largest copper manufacturing plant in the world (Evans, 2014; Newell, 1990; Swansea Museum, n.d-a). The port cities of Port Talbot and Pembrokeshire in South Wales continue to manufacture and export and import gas, oil and steel globally (Heley, Jones, & Watkin, 2015). Wales is known for its natural resources, particularly in the generation of energy (Winckler, 2015). Moreover, Wales is taking a leading interest in eco-innovation, such as environmentally friendly building materials and green energy alongside "adventure" tourism and hospitality to showcase the natural beauty of the nation (Centre for Alternative Technology, n.d; Heley et al., 2015). In rural areas, Wales is known for agriculture (e.g. 88% of the land is agricultural) and sheep farming (e.g. 29% of UK sheep farming is in Wales) (Armstrong, 2016; Bowen et al., 2018). The following UK map identifies Wales in blue (Figure 2.1).

Figure 2.1 Map of UK showing Wales in blue

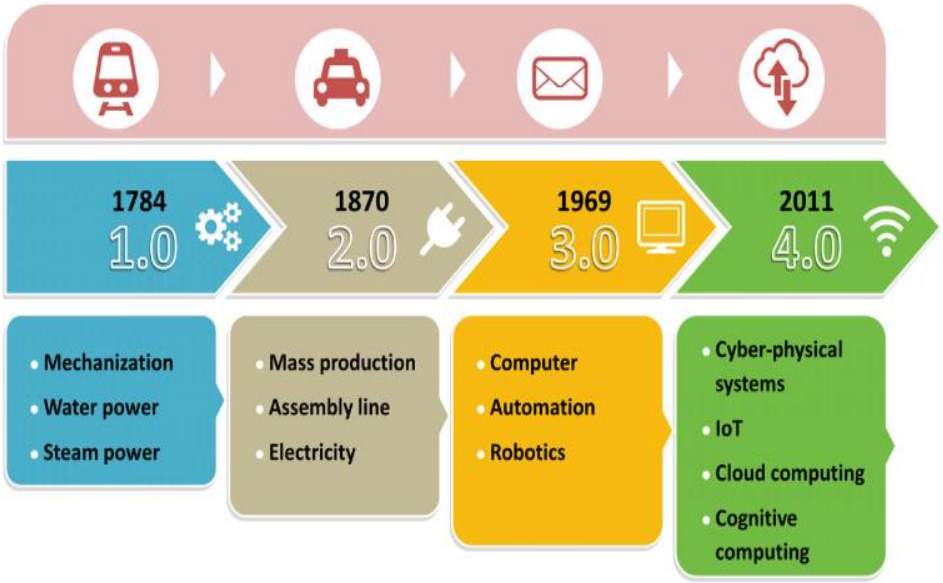
(Your free templates, n.d-b)



Since the 1970s, the Welsh economy and subsequent communities suffered devastating decline with de-industrialisation and the migration of mass manufacturing to other nations (Brill et al., 2015; Bristow, 2018). Later in the 1980s, it suffered additional losses with the destruction of the coal mining industry (Bristow, 2018).

In recent years, the Welsh Government has sought to recover these losses and stimulate the economy within the digital age and knowledge economy (Atos Wales, 2017; Swansea Bay City Deal, n.d). In August 2018, the National Assembly for Wales (NAW) issued a report making recommendations to engage in Industry 4.0, and to prepare and upskill the nation (NAW, 2018). Recommendations for automation, autonomous vehicles, artificial intelligence and precision agriculture to stimulate future growth opportunities and begin addressing the challenges posed by this new industrial revolution (European Commission, 2017; NAW, 2018). The historical revolutions leading to Industry 4.0 is summarised in (Figure 2.2).

Figure 2.2 Infographic of the History of Industry 4.0
(Your free templates, n.d-a)



In summary, Wales is working towards developing “full fibre & 5G” technologies to embrace the incoming fourth industrial revolution.

2.1.2 Welsh geography & demographics

Wales is a small and mountainous country to the west of England and the east of Northern Ireland across the Irish Sea. The country is 201 km (124 miles) from north to south, and 149 km wide (92 miles) from east to west (World Atlas, 2019). The total landmass of Wales is nearly 2.1 million hectares, of which 80% is considered agricultural land (Welsh Government, 2016). The main urban centres surround the four main University cities; the capital city Cardiff (population 361,500) and Swansea (population 239,023) in South Wales, Aberystwyth (population 18,093) in West Wales, and Bangor (population 17,988) in North Wales (Nomis, 2019b; Welsh Government, 2016).

2.1.3 Local authority administration

Wales is divided into 22 local authorities (LA), or unitary authorities (UA) (previously named parishes), for governmental administrative purposes (InfoBase Cymru, 2019; ONS, 2019). The Government of Wales Act 2006 created the Welsh Local Government Association (WLGA) and subsequent Regional Partnership Boards (RPB) to coordinate and represent local government organisation alongside the Welsh Government and Westminster (WLGA, 2019). The RPB is sub-divided into three regions: Central and South Wales, South East Wales and North Wales (InfoBase Cymru, 2019). The three RPB and 22 local authorities are (Business Wales, n.d):

1. North Wales - Conwy, Denbighshire, Flintshire, Gwynedd, The Isle of Anglesey & Wrexham.
2. Central and Southwest Wales - Carmarthenshire, Ceredigion, Pembrokeshire, Powys, Neath Port Talbot & Swansea.
3. Southeast Wales - Blaenau Gwent, Bridgend, Caerphilly, Cardiff, Merthyr Tydfil, Monmouthshire, Newport, Rhondda Cynon Taf, Torfaen & Vale of Glamorgan.

The Office of National Statistics (ONS) subdivides the local authorities into local areas and then into various “layers” based on population statistics (ONS, 2019). Local areas are therefore organized as follows (InfoBase Cymru, 2019):

Upper Super Output Area (USOA) – approximately 25,000 people

1. Middle Super Output Area (MSOA) – approximately 7,700 people
2. Lower Super Output Area (LSOA) – approximately 1600 people
3. Output Area (OA) – approximately 400 people

In addition, each area constitutes communities, which are considered the lowest tier of local government. In Wales (ONS, 2019), there are 878 communities, and approximately 768 are represented by community councils (p. 5). For the purposes of this study, the geographical area for research will be the Output Area (OA) level in rural areas with a focus on rural communities under 400 people because these are the "final few" and hard to reach areas (ONS, 2013).

The rural/urban classification sub-divides the unitary units into two urban and four rural classifications (ONS, 2016; Pateman, 2011). Urban is classified as greater than 10,000 population and divided into "urban-less sparse" and "urban-sparse" categories. The four rural classifications are "town & fringe - less sparse"; "town & fringe – sparse"; "village, hamlet & isolated dwelling – less sparse"; and "village, hamlet & isolated dwelling – sparse".

Classifying rural and urban areas is difficult which leads to alternative definitions in use across different official bodies. In August 2013, the Department for Environment, Food & Rural Affairs (DEFRA), the Department for Communities & Local Government (DCLG), the Welsh Government and the Office for National Statistics (ONS) combined efforts to provide a more comprehensive structure for rural-urban classifications particularly for small geographies (ONS, 2013). The small statistical geography is divided into a settlement (population) and context (density) based on 2011 Census data; hereafter referred to as the rural-urban classification 2011 (RUC2011). To classify settlement areas (ONS, 2013), RUC devised geographical grids of rectangular cells of 100 metres by 100 metres and *"each cell covers a geographic area of one hectare (10,000 sq. metres)"*(p. 11). RUC refers to these geographic grids as *hectare cells*. Density or "sparsity" can be estimated using hectare cells and the average number of residential dwellings within 10 km, 20 km or 30 km radius inside the OA. "Sparse" dwellings represent the lowest population level and often struggle with the delivery of services because of the lack of commercial viability

(Wales Rural Observatory, 2009). Thus, the rural classification of "rural village, hamlet & isolated dwelling – sparse areas" will be the focus of this case study. DEFRA summarises the geographical classifications with a coding system (Table 2.1).

Table 2.1 Summary of user guide for DEFRA RUC2011 small geographies (ONS, 2013)

Output Area	Description	Code
Urban	Major Conurbation	(A1)
Urban	Minor Conurbation	(B1)
Urban	City & Town	(C1)
Urban	City & Town in Sparse Setting	(C2)
Rural	Town & Fringe	(D1)
Rural	Village	(E1)
Rural	Village in Sparse Setting	(E2)
Rural	Hamlets & Isolated Dwellings	(F1)
Rural	Hamlets & Isolated Dwellings in Sparse Settings	(F2)

In summary, the small geographies coding is used for administration and the allocation of funding. For example, eligibility for the Gigabit Broadband Voucher Scheme defines "rural" following DEFRA and states Wales eligibility as D1-F2 coded areas (DCMS, n.d-b). Henceforth, the DEFRA code (F2) will be used to identify the final few and hard to reach area of interest for this thesis.

2.1.4 Regional context: Pembrokeshire – Case study area

The case study area chosen complies within the definition of "rural village, hamlet & isolated dwelling – sparse areas" (F2) and is located in the county of Pembrokeshire. Pembrokeshire is in Southwest Wales and considered a deep rural area that qualifies it as a case study area of interest. Furthermore, Pembrokeshire is near to this researcher, which provides easier access for in-depth study. Mr. G (Local IT Expert), previously interviewed, lives in a deep rural Pembrokeshire hamlet and will act as a gatekeeper by providing access and contacts in the surrounding hamlets and villages in the OA.

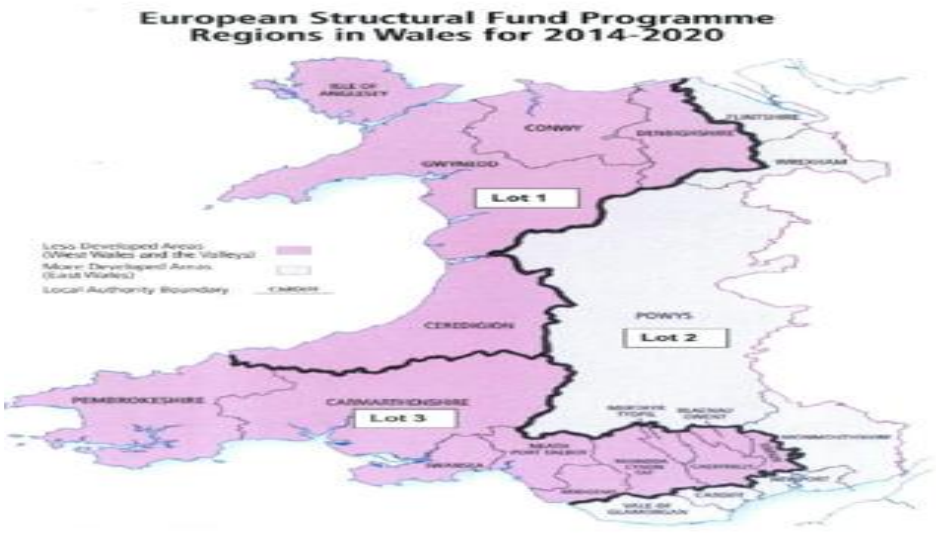
The Pembrokeshire County Council (PCC) lists ten Town Councils which serve the urban areas: Fishguard & Goodwick, Haverfordwest, Milford Haven, Narberth, Newport Town, Neyland, Pembroke Dock, Pembroke Town, St. David's and Tenby

(PCC, 2019). In addition, the Pembrokeshire Town & Community Councils (PTCC) lists sixty-seven Community Councils serving the rural areas (PTCC, 2019).

The 2011 Census estimates the population of Pembrokeshire at 122,439 and 60,712 households (Nomis, 2019a). Nomis provides local area reports which breakdown postcodes into Wards, Parish, Local Authority, Output Area and Lower-Layer SOA statistics (Nomis, 2019a). The broader case study Ward area states there were 434 residents at the Census 2011 and 179 households. The average age of residents was 44.7 years, and out of the 202 working residents aged 16 to 74, the primary employment industry sectors are human health & social work activities (14.4%); agriculture, forestry & fishing (13.4%); education (11.9%), construction (9.4%), and wholesale & retail trade; repair of motor vehicles & motorcycles (9.4%) (Nomis, 2019a).

The Welsh Government presented an up to date strategy and recent statistics at the Rural Gigabit Event (INCA, 2019, May 24). In the following (Figure 2.3), Lot 3 is Pembrokeshire, identified as the case study area. According to the Welsh Government, there are 8554 white premises in Pembrokeshire and 3418 under review. White premises are defined by the European Union (EU) single digital market as areas where *"no high capacity broadband infrastructure exists"* (Broadband Glossary, n.d.). Thus, more work is required in this area.

Figure 2.3 White premise statistics (Lot 3) - Welsh Government (INCA, 2019, May 24)



2.2 Defining rural communities

Alongside defining the demographics and administrative organisation of deep rural communities in Wales, it is important to define what is meant by "rural". Rural communities are understood to have lower population densities, harder to reach topography for services, which affects return on investment (ROI), and are often recipients of heavy subsidies (Halseth et al., 2019; Wales Rural Observatory, 2009). Nevertheless, recent research in remote villages in China have shown that rural communities do not need to be perpetual aid recipients and with the right critical success factors (CSFs) can become income-generating centres of innovation (Leong et al., 2016). Before engaging in innovative solutions, it is necessary to define rural communities and what is meant by rural, community, capital and ecosystems within an advanced broadband or next generation access (NGA) context.

Defining rural communities is challenging (Flora, 2016; Shucksmith, Brown, Shortall, Vergunst, & Warner, 2012). Flora (2016) defines "rural" and "community" separately. The author argues governments often direct definitions and labels for administrative purposes, or academics for analytical purposes, or marketing for sales or advertising purposes (p. 4). Hence, as explained in (Section 2.1.3), a joint UK Governmental effort was required to define rural areas for improved accuracy and analysis. The Department for Environment, Food & Rural Affairs (DEFRA), the ONS, the Department for Communities & Local Governments (DCLG), and the Welsh Assembly Government (WAG) combined to publish a new rural-urban classification based on Census 2011 (ONS, 2013; Pateman, 2011). For uniformity and consistency in analytics, academics often use governmental classifications to structure research. Thus, the new rural-urban classification (RUC2011) is used here to define rural communities in Wales.

2.2.1 Defining rural

In the United States of America (USA), Flora (2016) defined rural through population size, regional or place boundary specifications, and funding eligibility criteria (e.g. cut-offs for rural programmes such as business loans or housing) (pg. 5). In the UK, Shucksmith et al. (2012) state defining rural can be either statistical (e.g. population, metropolitan or non-metropolitan areas) or conceptual, but in the UK, there is no agreed statistical definition of what is rural. Pateman (2011) equally explains the

difficulties in classifying rural definitions in England, Northern Ireland, Scotland and Wales. Nonetheless, the rural-urban classification (RUC2011) uses population, and regional or place boundary specifications, like the USA structures, but with predominantly different terminology (e.g. the USA uses "county" designations, while the UK uses "local authority" designations). Hence, the geography delineations for governmental administrative purposes is similar.

In the UK, Townsend, Sathiaseelan, Fairhurst & Wallace (2013) explain defining rurality is difficult but introduce two categories. One is by local geography (e.g. distances from urban & population density), and the other by sociology (e.g. attitudes, beliefs & lifestyle) (p. 581). The authors continue to describe the current changes to rurality through access and mobility (e.g. travel difficulties), demographic distinctions (e.g. older residents), globalization and in-migration (p. 582).

2.2.2 Defining communities

Defining communities can similarly be a multi-disciplinary pursuit by demographics, geography or sociological features (Flora, 2016). Sociologists have a more difficult time defining community versus a geographer who can define it by boundary identification, ordnance maps, or postcode analysis. Sociologists define community, or groups of people, through various concepts; namely common identity (e.g. shared sense of identity), location (e.g. place) and social systems (e.g. organisations which meet their needs) (Flora, 2016, p. 9).

In the USA, Sterns, Adams & Boarse (2011) define communities as the sum of their collective parts, and are characterized *"by the relationships, networks, activities and functions that the individuals create and build together"* (p.159). The authors identify three forms of social capital, citing Putnam's 1993 definition, that facilitates the coordination of networks, norms and trust. Namely participatory capital (e.g. allowing people to bond and engage through volunteering activities). Network capital (e.g. social ties that contribute to community participation), and digital capital (e.g. use of digital communications to foster local participation) (p. 160).

For purposes of this study, the demography, geography and sociology of the rural community will be engaged as a collective whole. In the context of this research, the community can be defined as a group of people sharing space in a specific locality to

engage rural capitals for collective benefit. This research aims to investigate how communities can be engaged, and thus studies defining community development are worth noting.

2.2.2.1 Community development definitions

Shucksmith (2000) cites Shortall's 1994 definition of *"the community development approach of the 1950s, like that of LEADER today, tended to view 'community' as a group of people with common interests, living in the same geographical area, and frequently feeling a sense of 'community spirit'* (p. 209). LEADER (Liaison entre actions de développement de l'économie rurale) is an on-going and evolving European Union (EU) "bottom-up" initiative used to promote economic growth in rural regions at the local level (Shucksmith, 2000).

In the USA, Gallardo (2018) introduces the "Intelligent Community Outreach Programme" (ICOP) to assist rural communities in developing action plans to engage with the digital age. Gallardo (2018) cites Christenson & Robertson's 1989 definition of community development as a *"group of people in a locality initiating a social action process (e.g. planned intervention) to change their economic, social, cultural and/or environmental situation" (p.2).*

The community development definitions reflect the current rural community-led broadband schemes, where the sense of community spirit and collective action have achieved their goals of receiving SFBB (Section 3.5.1). In some, but not every case. Salemink, Strijker & Bosworth (2017a) state that although shared or collective vision to resolve a common problem, such as broadband is unifying, the complexity of the rural context must be considered. The authors cite Lee et al. (2005), Woods (2007) and Barrett (2014) explaining *"rural is a diverse spatial entity that includes many different social groups and stakeholders with both internal (or local) and external relations" (pg. 560).* Thus, the complexity of internal and external relationships needs to be considered for successful implementation of community goals.

2.2.3 Defining rural capital

Flora (2016) defines capital as "*resources capable of producing other resources"* (p. 206). Defining rural capital can be more easily achieved if the identification, or labelling, of assets is considered. According to Flora (2016), every community,

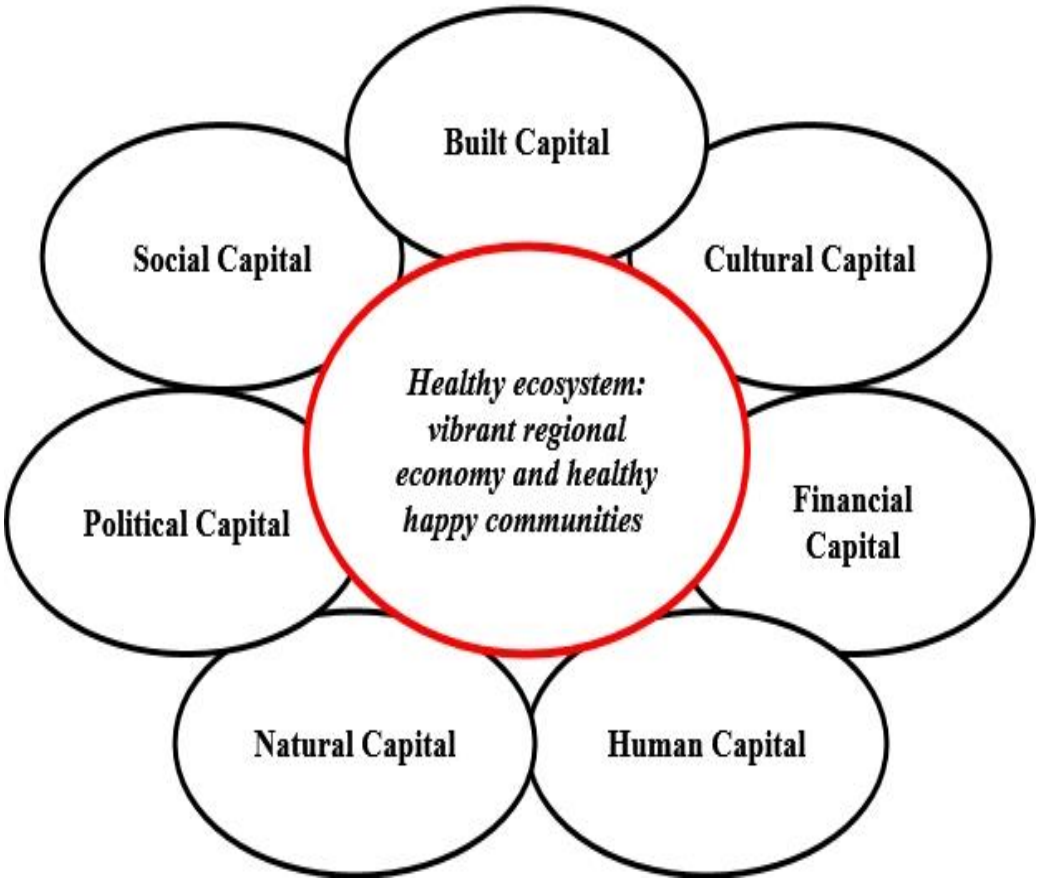
regardless of socio-economic status, has assets and when they are invested in creating something new, they become capital (p. 11). The author draws from well-known scholars and sociological concepts to define the various assets available to rural communities. The author cites noted "capital" scholars such as Becker (1994), Bourdieu (1986), Coleman (1988), Putnam (1993), Schultz (1961) and Weber (1978) to name a few. The author created a "Community Capital Conceptual Framework" by identifying seven forms of capital available to rural communities: built, cultural, financial, human, natural, political, and social capital. All the capitals, or assets, can be cultivated or squandered, according to each community's propensity to collaborate and act.

Not all the capitals will be included in this study. In the UK, researchers funded by the Research Council UK (RCUK), define rural capitals in context of SFBB studies and will be explained in the literature review (Chapter Three). Nevertheless, as a starting point, Flora (2016) defines rural capitals as the following (p. 11) and visualised in the Community Capital Framework (CCF) in (Figure 2.4).

1. *Built capital (BC)* - is human-constructed infrastructure (e.g. community broadband network). It is often equated to community development, but it is effective only when it contributes to other community capitals.
2. *Cultural capital (CC)* – determines how one sees the world, what one takes for granted, what one values, and what things one thinks are possible to change. Cultural hegemony allows one social group to impose its symbols and reward system on other groups.
3. *Financial capital (FC)* – includes savings, income generation, fees, loans, credit, gifts, philanthropy, taxes and tax exemptions. FC is much more mobile than the other capitals and tends to be privileged because it is easy to measure. Community financial capital can be assessed by changes in poverty, firm efficiency, diversity of firms, and increased assets of local people.
4. *Human capital (HC)* – characteristics and potential of individuals determines by the intersection of nature (genetics) and nurture (social interactions & the environment). HC includes education, skills, health and self-esteem.

5. *Natural capital (NC)* – includes air, water, soil, biodiversity and weather that surrounds us and provide both the possibilities and the limits to community possibilities. NC influences and is influenced by human activities.
6. *Political capital (PC)* – is the ability of a community or group to turn its norms and values into standards, which are then translated into rules and regulations that determine the distribution of resources. PC is also mobilised to ensure that those rules, regulations and resource distributions are enforced.
7. *Social capital (SC)* – involves mutual trust, reciprocity, groups, collective identify, working together, and a sense of shared future. Bonding SC consists of interactions within a specific group or community and bridging social capital consists of interactions among social groups.

Figure 2.4 Community Capital Framework (CCF)
(Emery & Flora, 2006, p. 32).



2.2.3.1 Defining financial capital

Financial capital in a rural broadband context has a variety of sources. The UK Government provides information on six different funding models rural communities can choose to engage with (e.g. bespoke supplier owned & operated, buy-into existing commercial or publicly funded roll-out, community-owned & operated, community-owned & supplier operated, or demand aggregation) (DCMS, 2019b).

Additionally, previous studies have revealed financial capital for rural broadband implementation come from local community fundraising, charitable contributions, cooperatives, government subsidies, investment loans, social enterprise schemes to name a few (Cybermoor, 2016; Wallace et al., 2015). Details of financial capital options will be explained in more detail in the literature review (Chapter Three).

2.2.4 Defining rural ecosystems

The term ecosystem originates from ecology and the interrelationships of organisms in their environments (Ashmore et al., 2017). It is a term used in many disciplines to describe an enclosed space that interacts with other organisms or actors within that unit (e.g. human body & so forth) (Ecosystem, n.d.). The definition of an ecosystem for business management research is "*something (such as a network of businesses) considered to resemble an ecological ecosystem especially because of its complex interdependent parts"* (Ashmore, 2015). Hence, making it a useful term when discussing multi-stakeholder engagement within this thesis.

The UK Government is using the term ecosystem to describe and build the 5G "network of networks". In a special online summary edition of phase one 5G testbeds and trial outcomes, there is a notable shift from *"hierarchical ego-systems to collaborative digital ecosystems*" which will change economics and society; the 5G testbeds and trials are confirming that *"collaboration is a hallmark"* for today's leaders (UK5G, 2019, p. 51)

Definitions for ecosystems in business research can vary. Roche & Jakub (2017) use a general definition to identify a market ecosystem where products are to be sold or engaged. In a rural ICT context, it depends on the evaluation of the sample and the area under investigation. A recent study in China (Leong et al., 2016) showcased an

ICT e-commerce platform and how this platform created an ecosystem for economic growth in two remote rural villages.

Some examples of the various ecosystem definitions taken from recent studies are summarized in the following (Table 2.2). The context of these definitions will be explained further in the literature review (Chapter Three). Table 2.2 provides a snapshot of the terminology to be used in this thesis. The Hybrid Value System (HVS) and the value ecosystem will be utilised as part of the methodology (Chapter Four). If the case study area has access to e-commerce platforms (e.g. Amazon web services), then a rural e-commerce ecosystem can be promoted (Wilson et al., 2018). The China case study revealed grass-root entrepreneurs, including disabled people, who were able to work from home and remain in their communities (Leong et al., 2016). These terms and concepts will be discussed further in (Chapter Three).

Table 2.2 Ecosystem definitions from "final few" literature

Term	Definition	Literature
Ecosystem (commerce)	A group of businesses or business activities that affect each other & work well together.	(Ecosystem (commerce), n.d)
Hybrid Value System (HVS)	An ecosystem that relies on connecting the core assets of several stakeholders.	(Roche & Jakub, 2017)
Value Ecosystem	Identifying CSO (citizen social organisations) within the community who have a significant amount of human & social capital within the community.	(Roche & Jakub, 2017)
ICT Ecosystems	The broad array of actors & roles that constitute an e-commerce ecosystem.	(Leong et al., 2016)
Rural e-commerce ecosystem	Grassroots entrepreneurial leaders - capturing ICT innovation through e-commerce & in turn inspired the local community to get involved.	(Leong et al., 2016)

2.2.5 Defining rural four-fold capital benefits – Outcome of SFBB supply

As explained in the introduction (Section 1.4) and in the Superfast Cornwall and Microbusiness pilot projects (Section 2.3.6.3), numerous academic and governmental research have confirmed that SFBB provides four-fold human, social, environmental and financial capital *benefits* for rural communities and MBs. For example, the ability to work from home with reliable SFBB increased productivity (e.g. human capital), impacted business growth (e.g. financial capital), less travel lowered carbon footprints (e.g. environmental capital) and reduced outmigration allowing communities to remain intact (e.g. social capital) (Cardiff University, 2019; Pant & Odame, 2017; Roberts,

Anderson, Skerratt, & Farrington, 2017a; SERIO, 2015; SQW, 2013). Thus, the outcome of SFBB has four-fold capital benefits on rural communities and MBs.

2.3 Rural stakeholder ecosystem

As explained in the introduction (Section 1.3), the UK Government is taking bold steps to achieve "full fibre & 5G" by 2033 (DCMS, 2018b). The May 2019 announcement of the Rural Gigabit Connectivity (RGC) programme aims to work from the "outside-in" starting with remote rural area connectivity of schools and health centres. Much coordination is required between government, local authorities, commercial suppliers and rural communities to achieve these goals (Jackson, 2018, October 23). Recent studies in Canada equally advised engaging alternative models to bridge the digital divide and to replicate community broadband initiatives by *"including government financial assistance and training supports, as well as local leadership and stakeholder collaboration"* (Halseth et al., 2019, p. 155). Hence, the engagement of multiple stakeholders is suggested to resolve the digital divide.

This section will identify the various rural stakeholders, or actors, playing a part in resolving the supply and demand challenges in rural communities. Rural stakeholders can be defined on the supply-side as governmental (e.g. local, national & supra-national) and commercial suppliers (e.g. alternative networks & major commercial suppliers). The demand-side can be defined as rural communities constituting local digital champions (LDCs), local citizen organisations (CSOs), microbusinesses (MBs) & residents (Section 2.3.6). Each of these individual stakeholders has needs, opportunities and barriers to overcome and will be explained accordingly.

2.3.1 UK Government - Rural Gigabit Connectivity Programme (RGC)

As explained in the introduction (Section 1.4) the UK Government recently changed the name of "Broadband Delivery UK" to "Building Digital UK" (BDUK) to reflect the step-change in full fibre and 5G connectivity. The RGC programme was launched in May 2019 to start connecting remote rural communities (DCMS, 2019c).

The background to rural connectivity, evolved out of the UK Government "Superfast Broadband Programme" (formerly the Rural Broadband Programme) which was rolled out in three separate phases. Phase One received £530m to reach 90% of the UK by 2016. Phase Two received £250m to reach 95% of the UK by 2017.

Phase Three received £10m pilot scheme to test options to reach the final 5% (House of Commons, 2014; NAO, 2015). The SFBB programme was intended to get SFBB to predominantly rural areas where commercial suppliers had no plans to invest (NAO, 2015). In Phases One and Two, grants were given to 44 local authorities, of which BT won all the contracts, but with "claw-back" or "gain share" clauses when 20% of premises took-up the service (House of Commons, 2014; Hutton & Baker, 2018). The claw-back clause was to re-coup and re-invest the public monies and profits when subsidising commercial broadband infrastructure investment in the commercially non-viable areas (Hutton & Baker, 2018).

The UK Government launched new funding schemes to complement the rollout. The new and existing initiatives to connect the 10% (FTTP) are detailed in the following (Table 2.3).

Table 2.3 UK Government funding programmes for rural connectivity (as of July 2019)

UK Government Programmes	Funding
Local Full Fibre Networks (LFFN): Programme Overview (DCMS, 2019a)	The LFFN programme is designed to stimulate commercial investment in full-fibre networks in both rural & urban locations across the whole of the UK. Funding for the programme is drawn from a total of £740m from the National Productivity Investment Fund which has been allocated to LFFN & the 5G Testbeds & Trials programmes over the next four years.
Local Full Fibre Networks (LFFN): Challenge Fund (DCMS, 2018d)	The LFFN programme launched its £190m Challenge Fund on 22 November 2017. The Challenge Fund is a capital grant programme which funds locally led public connectivity projects that have the potential to leverage commercial investment in full-fibre broadband connections. Local bodies were invited to submit formal bids to the Challenge Fund to help harness public sector connectivity & aggregate private sector demand in their local areas. The first £95m of funding was allocated in March 2018 to 13 successful bidders that were announced in the Chancellor's Spring Statement. The next £95m of funding is now open to local bodies for expressions of interest.

Local Full Fibre Networks (LFFN): Better Broadband Voucher Scheme (DCMS, 2019a)	The Better Broadband Voucher Scheme is in place to provide an affordable, *basic broadband* installation to homes & businesses that are unable to access a broadband service with a download speed of at least 2 Mbps & will not benefit from the Superfast broadband roll out within the next 12 months. Households & businesses that are eligible to take advantage of the scheme have the installation & hardware costs of their connection subsidised to ensure their first-year costs are no more than £400. The subsidy is used to fund a variety of technological solutions including satellite, 4G & fixed wireless.
Local Full Fibre Networks (LFFN): Gigabit Broadband Voucher Scheme (DCMS, 2019a)	In March 2018, the LFFN launched a £67m Gigabit Broadband Voucher Scheme. Gigabit broadband vouchers can be used by small businesses & the local communities around them to contribute to the installation cost of faster connections using gigabit-capable infrastructure. Small to medium-sized businesses can claim a voucher worth up to £2,500 & residents can claim a voucher worth £500 as part of a group project.
Rural Gigabit Connectivity (RGC) Programme: Overview (DCMS, 2019c)	The RGC programme commenced on 19 May 2019 & will run until the end of March 2021. The Future Telecoms Infrastructure Review, published in July 2018, identified that approximately 10% of UK premises, largely in rural & remote locations, would be unlikely to receive gigabit-capable (full-fibre) connections by 2033.
Rural Gigabit Connectivity (RGC) Programme: Gigabit Voucher Scheme (DCMS, 2019a)	As part of the RGC programme, BDUK has adapted the existing Gigabit Broadband Voucher Scheme to support the delivery of full-fibre connectivity in rural areas. Businesses & homes in the hardest to reach areas of the UK may be eligible for funding towards the cost of installing full-fibre broadband to their premises when part of a group project. Rural premises with broadband speeds of less than 30Mbps can use vouchers worth up to £3,500 for each SME & up to £1,500 per residential premise.

These updated programmes and funding schemes play a role in what community support and financial aid individuals and communities can receive in areas not covered by Superfast or Basic Broadband schemes. Eligibility for gigabit broadband vouchers was explained in (Section 2.1.3, Table 2.1).

2.3.2 Welsh Government – Business Wales & Superfast Cymru

The UK Government is responsible for the roll-out of telecommunications across the nation, but the Welsh Assembly (WA) (changed name to Senedd/Welsh Parliament in May 2020 but will be referred to as WA for this thesis to maintain context of literature at time of writing) has devolved powers which does not necessarily include owning

the responsibility of "full fibre & 5G" roll-out. Nevertheless, the Welsh Government (civil service arm), WA (political arm) and the local authorities are actively participating in how to support the UK Government initiatives, with their supplementary initiatives to resolve the digital divide for Welsh citizens.

2.3.2.1 Superfast Cymru

In 2012, the Welsh Government instituted *Superfast Cymru,* in contract with BT, to deliver SFBB to 95% of premises across Wales (Welsh Government, 2018). The goal was predominantly reached at the end of 2017 (Digital Communities Wales, 2016). In February 2018, the delivery phase of Superfast Cymru closed, but the successor project "Taking Wales Forward" programme for 2016-2021 allocated £80m of public funds, plus claw-back or gain shares from previous Superfast Cymru projects, to target an additional 88,000 properties with UFBB (Hutton & Baker, 2018). The new contract organised specific allocations for "community programmes" which were divided into three lots: North Wales (Lot 1), East Wales (Lot 2), South-West and the Valleys (Lot 3) (p. 31).

The Welsh Government recently awarded BT a further £13m for Lot 1 (North Wales) and Lot 3 (South Wales) (Jackson, 2018, October 23). According to the report, Lot 3 (Southwest Wales) intervention area of 35,166 NGA white premises has been identified. To support FTTP connectivity, the government is offering gigabit vouchers to small businesses and residents (DCMS, 2019d). These investments will help bridge the gap, but the challenges of viable business cases, community cooperation, finances, geography, technology and topography remain for the harder to reach areas (INCA, 2019).

Paradoxically, the Welsh Government recently stated that the market appetite for FTTP, even with subsidies, may not be forthcoming (Jackson, 2019, May 14). No other bidder accessed the £80m funding scheme, except for BT. Lee Waters AM, Deputy Minister for Economy & Transport, concluded the market is not interested in applying for subsidies. The Welsh Government is *"looking now at non-conventional interventions, because we do think that FTTP is reaching the limits of what the market is willing to provide"* (Jackson, 2019, May 14).

Despite this assertion, the Welsh Government have adjusted their additional funding schemes to connect the 10% are detailed in the following (Table 2.4).

Table 2.4 Welsh Government funding scheme for rural connectivity (as of July 2019)

Welsh Government Programme	Funding
Superfast Cymru programme: Access Broadband Cymru (ABC) Vouchers (Welsh Government, 2017)	The Superfast Cymru programme is aiming to deliver SFBB by the end of 2017 to areas across Wales which are outside the roll-out plans of the private sector. Complimenting this programme is the ABC Cymru Scheme, which provides grant support to install alternative broadband solutions capable of delivering stable superfast download speeds. New connections through this scheme must deliver a step-change in speed - with at least double your current download speeds, e.g. a current connection of 10 Mbps must improve to at least 20 Mbps. £400 for 10Mbps & above £800 for 30Mbps & above
Additional funding for Welsh Premises: Gigabit Broadband Voucher Scheme: (DCMS, 2019a)	From 22 March 2019, business & residents in Wales are eligible for additional funding from the Welsh Government towards the cost of installing gigabit-capable broadband to their premises when part of a group project. Group projects are when two or more businesses get together – or businesses with residents – to combine their vouchers towards the cost of connections. Up to ten residents can get together with one business to create a group community project. Additional funding: £3,000 per small and medium-sized business (SME) & up to £300 more per resident to help connect harder to reach places in Wales.

These additional funding schemes, on top of the UK Government schemes, will provide more options for deep rural Wales communities to secure funding for access solutions. The Welsh Government hinted at introducing a "novel scheme" to support communities by seeking to establish a broadband outreach team "*to work with clusters of homes and businesses to harness this demand, define a local project, and process a solution"* (Hutton & Baker, 2018, p. 32).

2.3.3 Local Authority – Pembrokeshire

One of the challenges for local government is the lack of digital skills or market awareness, and subsequent lack of interest, motivation or training to promote the exploitation of SFBB, let al.one Industry 4.0 (Knight, 2015; Philip et al., 2015b). According to an observation by Openreach, BT won 50 individual contracts for counties and groups of counties. BT tried to encourage demand stimulation and training, but only 10% of local authorities adopted the strategy. The BDUK message was the more local authorities promote demand stimulation, the more claw back profits can be used for re-investment (e.g. if 20% take up the service, then 75% can be used by the local authority). Somewhere there is a disconnect between local authorities and SFBB awareness and exploitation, which needs to be addressed if rural communities are to experience the four-fold capital benefits.

2.3.4 Openreach (BT) – National infrastructure provider

BT has enjoyed a dominant national status because of the inheritance of the post office and the copper telephone wire infrastructure, which covers 99% of the UK (House of Commons, 2014). Throughout the Superfast Broadband Programme, BT has received approximately £1.7bn in public sector funding within Phase One and Two local authority contracts (NAO, 2015). Both phases use a "gap funding" model whereby the government fills the gap where commercial supplier investment in broadband infrastructure is not viable (p. 9).

One of the problems with Phase One and Two was the lack of competition in the market (NAO, 2015). Complaints from competitors to Ofcom, put pressure on BT to separate Openreach from its consumer operations. Openreach is a wholesale-only supplier, and its separation from BT is intended to open the networks and provide competition in the market (Cadman, 2019).

Additional technical terms need to be defined to explain the challenges facing rural areas and explained in the following (Table 2.5).

Table 2.5 Technical terminology to explain challenges facing rural areas

Term	Definition	Resource
Backbone	A local backbone refers to the main network lines that connect several local area networks (LANs). The result is a wide area network (WAN) linked by a backbone connection. Just like the human backbone carries signals to many smaller nerves in the body, a network backbone carries data to smaller lines of transmission.	(Christensson, 2006a)
Backhaul	The physical part of a communications network between the central backbone & the individual local networks.	(Backhaul, n.d)
Ethernet	Ethernet is the standard way to connect computers on a network over a wired connection. It provides a simple interface & for connecting multiple devices, such as computers, routers & switches. With a single router & a few Ethernet cables, you can create a local area network (LAN), which allows all connected devices to communicate with each other.	(Christensson, 2014b)
Headend	Equipment or a facility which receives communications signals (such as cable television broadcasts) for distribution to a local region.	(Headend, n.d)
Internet Service Provider (ISP)	A company that provides its customers with access to the Internet & that may also provide other Internet-related services (such as e-mail accounts).	(Internet Service Provider (ISP), n.d.)
Local Area Network (LAN)	A local area network (LAN) is a computer network within a small geographical area such as a home, school, computer laboratory, office building or group of buildings.	(Techopedia, n.d-b)
Network Service Provider (NSP)	An NSP is a business that provides access to the Internet backbone. While some ISPs also serve as NSPs, in most cases, NSPs provide Internet connectivity to ISPs, which in turn provide Internet access to customers.	(Christensson, 2014d)
Passive Optical Network (PON)	A PON is a telecommunications network that transmits data over fibre-optic lines. It is "passive" since it uses unpowered splitters to route data sent from a central location to multiple destinations. PONs are used by ISPs & NSPs as a cost-effective way to provide Internet access for customers. Since a PON is a point-to-multipoint (P2MP) system, it provides a more efficient way to transmit data than a point-to-point network. The main transmission line can split off into 32 separate lines, which requires far less infrastructure than building direct lines to each destination.	(Christensson, 2014e)

**Definitions taken from Merriam-Webster online dictionary, Tech Terms & Techopedia (Appendix A).*

Observations and discussions from Openreach Business Development for Local Full Fibre Network (LFFN) during the Rural Gigabit Conference (INCA, 2019, May 24) revealed some of the technical issues that need to be considered when discussing fibre. According to Openreach, fibre definitions should be clarified, so users understand what is meant by the term. The actual definition of fibre is *"a high-speed data*

transmission medium which contains tiny glass or plastic filaments that carry light beams" (Christensson, 2014c). If rural communities want full fibre, they can access it, but it is often packaged with an Ethernet connection, which can prove costly.

Ethernet connections run fibre from the *headend* (e.g. central telephone exchange, but not all telephone exchanges are considered a headend) to the premises and it is a *dedicated* line. No one else shares the connection. You get exactly what you pay for (e.g. one Gbps or 10 Gbps). Politicians refer to fibre as the shared commercially available broadband connections accessed through a passive optical network (PON) where you share the connection with 32 or more users on the same line. More specifically, multiple Ethernet connections can run over the PON, so the PON connection is shared even if each user has their own Ethernet connection (e.g. everyone shares the road even if they own their own car, but some people might share the road & a bus over the top). The Openreach backbone network is extensive but is not publicly accessible due to national security protection. Only commercial suppliers can write to Openreach to access the backbone network, hence the need for communities to engage with Openreach "Community Fibre Partnership (CFP)" (Openreach, 2019b), or collaborate with another commercial service provider, or an Altnet.

Openreach describes the network like a motorway. The existing motorway is extensive, but not all parts of the motorway offer full-fibre speeds because it requires upgrading. Openreach is investing in upgrading the commercially viable parts of the motorway. However, business development teams for LFFN are managing the off-ramps and areas that are not commercially viable, where public funding and collaboration opportunities are investigated (INCA, 2019, May 24). Openreach describes fibre as the motorway network, Ethernet as having your own car, and broadband is waiting for the bus to share with other people. The current state of play is that the motorway exists, but there are insufficient off-ramps, hence the need for government support and the inclusion of Altnets to help bridge this gap (DCMS, 2019a).

The backhaul question is the challenge for rural communities, particularly if they are out of the new rural gigabit "hub" catchment area (DCMS, 2019c; Halseth et al., 2019). Dark fibre networks (or not "lit up" or "switched on" fibre), the cross-country university high-speed network (JANET), railway networks and the proliferation of

wireless mobile communication masts across the UK are assets that rural communities need to consider (Janet Network, n.d; NAW, 2017). Another consideration when connecting to backhaul or backbone is fibre-to-the-cabinet (FTTC). FTTC requires power sources, so cabinets can only be built where enough power is available (e.g. streetlights in rural areas) (Rendon Schneir & Xiong, 2016). Ethernet or FTTP do not require additional power sources. Ethernet and FTTP can run straight from the headend power source to the home power source. Details of FTTC and FTTH/P and the complexities of building full fibre networks will be explained in (Section 5.10.2).

In summary, backbone and backhaul considerations are essential when discussing network architecture, and the various options and solutions for rural connectivity (Cybermoor, 2016).

2.3.4.1 Openreach Community Fibre Partnership (CFP)

To assist the final few and hard to reach communities, Openreach created the Community Fibre Partnership (CFP) programme. Areas qualifying for the CFP programme fall under the categories of those not able to get fibre broadband, are geographically too far away, or are excluded from current network deployment plans. The idea is to provide these rural communities that want faster broadband with a contact and process to partner with Openreach to find a solution (Openreach, 2019b). The CFP programme aims to share the financial burden by developing a joint funding agreement (e.g. shared financial capital) whereby Openreach covers some of the cost and the community funds the rest, which can include government subsidies where available.

In summary, BT and Openreach's reputation has suffered, in parts, as a result of rural broadband infrastructure roll-out. BT's negative brand reputation, alongside the government, has produced distrust amongst rural communities (Daily Telegraph Reporter, 2018, February 3). Nevertheless, with Openreach business development teams, CFP programme, collaborating with local governments, knowledge sharing with communities and Altnets, hopefully, trust, and brand reputation will improve.

2.3.5 Alternative Networks (Altnets)

According to the BDUK Market Test Pilot report (DCMS, 2016a), there are more than 40 smaller infrastructure providers in the UK and growing (Prism Business

Consulting, 2014). These smaller infrastructure providers are referred to as "alternative networks" or *Altnets*. The Independent Networks Cooperative Association (INCA) specialises in supporting rural communities acquiring "full fibre & 5G" services (INCA, 2012).

Recent OECD research highlights case studies in the UK for the successful implementation of UFBB and FTTH/P (OECD, 2018). Gigaclear, in particular, as an alternative network company, was making successful inroads into the hard-to-reach rural areas (OECD, 2018, p. 25) and was awarded by the FTTH Council Europe for its efforts (Jackson, 2018, February 14).

2.3.6 Rural Community – Demand ecosystem

Rural communities were defined in (Section 2.3) to describe the various capital assets available for investment and engagement. Statistics for rural communities were explained in (Section 2.1), particularly for the F2 rural case study identified in Pembrokeshire (Table 2.1).

During the UK Government Market Test Pilots (MTP) (DCMS, 2016a), rural communities such as Cybermoor (Cybermoor, 2016) revealed the challenges rural communities face when working alongside government, commercial suppliers, technicians and various funding options. This section will identify the various "demand-side" stakeholders within a rural community. It is within rural communities where valuable and often untapped human, social and environmental capital reside (Emery & Flora, 2006; Flora, 1998; Malecki, 2012; Roche & Jakub, 2017; Wallace et al., 2015).

2.3.6.1 Rural Local Digital Champion (LDC)

LDCs are an unequivocal critical success factor (CSF) in rural community broadband initiatives and for successful innovation project implementation (Ashmore et al., 2017; Leong et al., 2016; Rothwell et al., 1974; Wallace et al., 2015). Evidence of this will be explained further in the literature review (Section 3.6.4) because the value of local human & social capital cannot be underestimated.

2.3.6.2 Rural Citizen Service Organisations (CSO)

In Wales, predominant rural (CSO) are the National Farmers Union Cymru (NFU Cymru, n.d) and the Federation of Small Business Wales (FSB, n.d). Additionally,

local churches, community centres, schools and so forth can play significant roles in project implementation. These institutions need to be identified and engaged in garnering human, social, environmental, financial and political capital for rural community engagement.

2.3.6.3 Rural Microbusinesses (MBs) – Four-fold capital findings

As explained in the introduction (Section 1.3), microbusinesses (MBs) are vital to the UK economy and need to capitalise on innovation cycles, especially in rural communities (Schumpeter, 1959). Hence, MBs are essential stakeholders in the rural community ecosystem and for regional development (Baumgartner, Pütz, & Seidl, 2013; Lacohee & Phippen, 2015).

Prior to starting this thesis, this researcher was involved in a 6-week Swansea University i-Lab pilot project for British Telecommunications (BT) in July/August 2016, to investigate what MBs thought about current ICT provision and would they make use of the new UFBB service (unpublished Liu, Wu & Cope, 2016). The Microbusiness pilot project (2016) was asked to follow on from the Next Generation Broadband (NGN) Infrastructure project, known as Superfast Cornwall, which was the largest investment of SFBB into a predominantly rural area (Phippen & Lacohée, 2016; SERIO, 2015). The MB pilot project (2016) extended the work conducted by Phippen & Lacohee (2015; 2013) who investigated the impact of SFBB on rural MBs (0-9 employees) and communities in Cornwall.

The results of the SFBB Cornwall report (Lacohée & Phippen, 2013) revealed individuals could grow their businesses (e.g.) users could build websites to market beyond local boundaries. Receive and respond to new inquiries and process invoices more efficiently. Utilise social media for networking and make use of video conferencing and other web-based communication services that were not feasible with a slower Internet connection. The previous frustrations of not being able to use the Internet, due to slow connections, had been liberated, and people were able to extend their business and experience the four-fold human, social, environmental and financial capital benefits. Unfortunately, increased use inevitably slowed down the connection. Hence, continuous innovation of ICT provision (supply) and ICT skills training for adoption (demand) is required to grow and sustain the four-fold capital benefits.

In conjunction to SFBB Cornwall report, the Microbusiness pilot project (2016) revealed a demand for new products and services, urban markets have saturation, but rural markets are lagging in access, competitive pricing and service. As a result, there is negative reputational brand damage to ICT suppliers and local government due to the lack of rural market support. Henceforth, the need for further investigation into resolving rural supply and demand challenges evolved out of this analysis.

2.4 Conclusion of the research context

To conclude, the rural research context is complex with competing ideals, multiple stakeholders and various options available for NGA supply and demand problem resolution. The "supply-side" stakeholders (e.g. government & commercial ICT suppliers) and the "demand-side" stakeholders (e.g. rural communities, microbusinesses & CSOs) create a rural ecosystem which consists of individual barriers, challenges and opportunities to overcome if rural communities are to experience the four-fold human, social, environmental and shared financial capital benefits. Moreover, inside the rural ecosystem lies multiple capital resources that need to be identified and engaged.

The research questions (RQs) of what capital resources are required to support infrastructure to enable NGA to be viable for rural communities and microbusinesses in the "final few" and hard to reach areas requires multi-stakeholder engagement and innovative approaches (Section 1.7). Thus, the following chapter reviews the rural broadband and innovation management academic literature to determine what previous studies, methods, models and theories can be drawn upon to manage and measure this process.

Chapter Three: Rural Broadband & Innovation Analysis

3.1 Introduction & Chapter Overview

This chapter provides a review of the academic literature in the field of "rural areas & telecommunications" (Saunders, Lewis, & Thornhill, 2016). The review begins with a historical chronological background of telecommunications and ICT innovation, then evolves into a narrative analysis in support of concepts relevant to the research questions (RQs) (Bryman & Bell, 2015; Maxwell, 2010). The problem area described in the introduction (Section 1.5) identified the numerous challenges in providing NGA (product) to the "final few" and hard to reach rural areas (market) in the UK. Thus, the research objectives (OBJs) (Section 1.2) need to be explored to understand the problem area and validate the RQs (Section 1.6).

To set the parameters of the literature review regarding scope, inclusion and exclusion criteria, and the overall search methodology, analysis and summaries are explained in (Section 3.2). Following the search methodology and overall topic analysis, the first part of the literature review sets the historical foundation of the thesis within the telecommunications, ICT and innovation domain (Section 3.3). The primary resources and foundation of the literature review are explained in (Section 3.4).

Literature review - to answer the research objectives (OBJ1-3)

Community-led initiatives, supply and demand studies in reaching the final few and hard to reach rural areas will be evaluated in (Section 3.5) to answer (OBJ1A-C). Industry 4.0 and NGA drivers, opportunities, barriers and critical success factors (CSFs) for rural broadband will be discussed in (Section 3.6) to answer (OBJ2A-C). Human capital and social capital are identified as CSFs and will be reviewed as theoretical underpinnings for this thesis (Sections 3.6.5 & 3.6.6 respectively) contributing to (OBJ2D). Managing innovation in a digital age is difficult (Tidd & Bessant, 2009), particularly within complex multi-stakeholder ecosystems (Section 1.6). Hence, core concepts derived from ICT innovation such as co-creation, multi-stakeholder engagement and open innovation are assessed in (Section 3.7) to answer (OBJ3). The conceptual framework for rural community engagement is introduced in (Section 3.8). A final discussion and summary for further empirical research are

presented in (Section 3.9). Overall, technical terms and definitions will be addressed and listed in (Appendix A). Nevertheless, key terminology and definitions need to be confirmed at the outset of this thesis to understand the problem area and the subsequent search process.

3.1.1 Definitions & terminology

Prior to commencing the literature review, it is necessary to clarify some of the varying definitions and terminology used within the telecommunications and ICT domain. Terms such as “broadband”, “fibre-optic”, “next-generation access” and “superfast” are explained in the Table (3.1). Terminology definitions are taken from UK Government sources (Hutton & Baker, 2018), Office of Communication (Ofcom) glossaries (Ofcom, 2005) and Techterms.com (Christensson, 2010).

Table 3.1 Summary of technical terms & definitions for literature review

Term	Definition	Resource
Bits - not bytes	The smallest unit of measurement used to quantify computer data. The terms "bits" & "bytes" are often confused. Bits measure data transfer rates & are written with an abbreviated small “b”. Broadband is measured in bits per second to reflect data transfer speeds (e.g. Mbps). Bytes measure files, storage devices & story capacity & are written with an abbreviated large “B” & not used to measure broadband.	(Christensson, 2006c).
Broadband (basic)	Defined in the UK as speeds up to 2 Mbps.	(Hutton & Baker, 2018)
Fibre Optic Cables/Networks	A high-speed data transmission medium. It contains tiny glass or plastic filaments that carry light beams. Digital data is transmitted through the cable via rapid pulses of light. The receiving end of a fibre optic transmission translates the light pulses into binary values, which can be read by a computer.	(Christensson, 2014c)
Full-fibre broadband or FTTC/FTTH/FTTP	Fibre to the cabinet, home or premises	(Hutton & Baker, 2018)

Fifth Generation Wireless (5G)	Fifth-generation wireless (5G) is a wireless networking architecture built on the 802.11ac IEEE wireless networking standard, which aims to increase data communication speeds by up to three times compared to its predecessor, 4G & operates in the 5 GHz frequency mode. 5G is primarily designed to enable a superior data communication rate between wireless local area networks (WLAN), reach speeds up to 1.5 Gbps & cover a distance of 90 meters - three times more than 802.11n. The large coverage area for 5G is made possible through a technique called beamforming, in which the wireless routers ignore inefficient paths & deliberately neglect to record them in the routing table.	(Techopedia, n.d-a)
Gigabit Broadband	Over 1000 Mbps or one Gbps	(Christensson, 2013)
Information Communication Technologies (ICT)	ICT refers to technologies that provide access to information through telecommunications. It is similar to Information Technology (IT) but focuses primarily on communication technologies. This includes the Internet, wireless networks, cell phones & other communication mediums.	(Christensson, 2010)
Next Generation Access (NGA) – Ofcom glossary	New or upgraded access networks that will allow substantial improvements in broadband speeds & quality of service compared to today's services. Can be based on a number of technologies including cable, fixed wireless & mobile. Most often used to refer to networks using fibre optic technology.	(Ofcom, n.d)
Next Generation Access (NGA) – used by the European Union (EU)	Defines NGA broadband to be networks that consist wholly or in part of optical fibre cables that are capable of delivering broadband with enhanced characteristics compared to already existing copper networks	(Hutton & Baker, 2018)
Next-Generation Network (NGN)	An upgrade to the core or "backbone" part of the network.	(Ofcom, n.d)

Next-Generation User (NGU) – defined by Dutton & Blank at the Oxford Internet Institute (2011)	Someone who accesses the Internet from multiple locations & devices. Operationally define the NGU as someone who uses at least two Internet applications (out of four applications queried – browsing the Internet, using email, updating social networking site, or finding directions) on their mobile & who fits two or more of the following criteria: own a Tablet, own a reader, or own three or more computers.	(Dutton & Blank, 2014, p. 35)
New Universal Service Obligation (USO) – as of 2020	Defined in the UK as speeds up to 10Mbps.	(DCMS, 2016b)
Superfast Broadband (SFBB) – the term used by the UK Government to roll out NGA	Defined in the UK as speeds greater than 24Mbps, whereas Ofcom & the European Commission define it as speeds greater than 30Mbps. The Scottish & Welsh Governments also use the higher definition.	(Jackson, 2011, July 4)
Ultrafast Broadband (UFBB)	Defined in the UK as over 300Mbps.	(Jackson, 2015, December 1)

For purposes of this study, NGA defined by Ofcom will be used. As described in (Section 2.3.4) these are the technologies that can deliver superfast speeds, including FTTC and FTTH/P (Ipsos MORI, 2018). The term ICT will be used interchangeably with telecommunications. Ultimately, this study focuses on advanced broadband connectivity, but ICT is the overall umbrella term to include 5G and so forth. As explained in the introduction (Section 1.3) the vision and ambition of the UK Government (2018) is for the nation to receive full-fibre connectivity and make copper telephone lines obsolete.

3.2 Literature review search methodology

The overarching field of study is "rural areas & telecommunications", but the specific focus is "NGA in rural communities". The UK Government NGA roll-out began in 2010/2011 (Ipsos MORI, 2018). Thus, the literature review will concentrate on the 2010 to 2019 timeframe. Relevant UK broadband studies prior to 2010 will be considered to understand the historical challenges of implementing broadband infrastructure into rural areas. Inclusion and exclusion parameters are necessary to focus the study and to define the problem area (Smallbone & Quinton, 2011).

3.2.1 Inclusion & exclusion criteria

The following inclusion and exclusion criteria were used for all the database searches. Additional edits were made on subject, publication and the removal of technical articles.

Inclusion criteria focused on the UK, Europe and advanced western nations (e.g. Australia, Canada, New Zealand and the USA) to provide relevance with cultural, financial, language and political comparisons. The context of this study is the Government's Industry 4.0 ambitions and providing NGA throughout the UK. Hence, comparisons to countries with similar contexts were included.

Exclusion criteria focused on developing nations, or nations with different cultural, financial, language and political considerations. However, there are numerous studies in developing nations that focus on bridging the digital divide in rural communities. For example, Marais (2016) thesis in deep rural South Africa focuses on the social capital of Village Operators, recruited and developed as micro-entrepreneurs, to provide broadband to rural schools. The social capital study is specifically on the micro-entrepreneur's micro (family), meso (church) and macro (government project support) and how it did or did not aid in the sustainability of the project. The "concepts" to this thesis are similar, but the "context" is not the same. Hence, the need to scope the project to compare "like for like" and within the UK Government's Industry 4.0 and rural gigabit roll-out. The date limit was set to 2010-2019 because it corresponded with the UK's efforts to roll-out NGA.

3.2.1.1 Information Communication for Development (ICT4D)

One final inclusion/exclusion criteria to explain. The United Nations ICT4D studies are a particular academic field because the UN focuses on the "poorest of the poor" global regions (Marais, 2016). A number of these studies can be found in the journal *Technological Forecasting and Social Change*. A search for "rural & broadband" in this journal revealed (n=54) studies. Most of these articles are in sub-Saharan Africa, Mozambique, India, Indonesia and so forth. There are two EU articles but were excluded because one focuses on the quality digital divide (not rural broadband) (Vicente & Gil-de-Bernabé, 2010) and the other focuses on 5G (Oughton, Frias, Russell, Sicker, & Cleevely, 2018). Although the UK Government names 5G as part of NGA, this study focuses on fixed broadband (FTTH/FTTP) because wireless access

is problematic for the final few and hard to reach rural areas in Wales (e.g. geography with deep valleys & trees that obscure the line of sight for wireless) (Section 2.1). Similarly, studies focusing on community wireless networks (CWNs) as free or affordable wireless systems were excluded for this reason (Abdelaal, Ali, & Khazanchi, 2009, January) despite the value of social capital required to implement CWNs. The authors (2009) found hardware and money donations, developing open-source software (OSS), node-sharing and volunteerism were community social capital contributions that supported the implementation of CWNs. Nonetheless, wireless technology studies were considered out of scope to maintain the focus on advanced western nations FTTH and NGA access, but the social capital contributions are worth noting.

However, two studies were included that were outside of this remit. One is an MISQ article in China (Leong et al., 2016) on how deep rural communities do not need to be perpetual aid recipients (e.g. case study on two entrepreneurial leaders whose human & social capital achieved this). The other article was in Peru whereby two local leaders, whose human & social capital assisted the diffusion of ICT in deep rural communities (Díaz Andrade & Urquhart, 2009). These two articles were deemed of interest and relevance to this study as examples on how to successfully bridge the digital divide using non-financial capital. Overall, the subject area is rural broadband in the UK. Studies involving technical or subjects outside the core area were excluded.

A summary of the inclusion and exclusion search criteria (Saunders et al., 2016) used in the database searches are included in the following (Table 3.2).

Table 3.2 Summary of literature review scope criteria

	Inclusion Criteria	Exclusion Criteria
Language of Publication	English	Non-English
Subject Area/s	Rural Broadband, Community, Capital, Microbusinesses & Innovation literature.	(e.g.) bioeconomy, CSR, ethics, gender, ICT4D, industry, investing, migration, mobile, old age, policies, poverty, in-depth technical papers, venture capital & so forth.
Business Sector	Télécommunications, Information Communication Technologies (ICT).	(e.g.) automotive, biopharmaceutical, education, engineering, healthcare, hotels, industrial, medicine, transportation & so forth.
Geographical Area	Predominantly UK, European Union (EU) & Advanced Western Nations (e.g. Australia, Canada, New Zealand & USA).	Developing countries or countries with different language, political, financial & cultural differences (e.g.) Africa, Asia, Middle East, India.
Publication Period	Primarily 2010-2019 Relevant historical papers were included to frame the research.	The study focuses on next-generation access (NGA) or the UK "superfast broadband programme" roll-out from 2010/11.
Literature Type - primary	Association of Business School (ABS) ranked Peer-reviewed Journals, Conferences & Books.	Notable exceptions - Journals not appearing in ABS rankings, but with reputable publishers such as Wiley on-line were included (e.g. Sociologia Ruralis, which is the Journal of the European Society for Rural Sociology). Other journals not ranked by ABS, but with relevance to the study & RCUK funding were included (e.g. Scottish Geographical Journal).

Contextual secondary grey literature sources (Tier One) were retrieved from international, national, regional and local government, industry, and media relevant to the subject area and are summarised in the following Table (3.3).

Table 3.3 Summary of secondary grey literature – government, industry & media

Source	Field	Resource
Government	UK Government	(e.g.) Building Digital UK (BDUK), Department for Digital, Culture, Media & Sport (DCMS), Department for Environment, Food, Rural Affairs (DEFRA), Enterprise Research Council (ERC), House of Commons, House of Lords, Rural Gigabit Connectivity Programme (RGC), Office of Communications (Ofcom), Office of National Statistics (ONS), The Ministry of Housing, Communities & Local Government (formerly the Department for Communities & Local Government (DCLG).
	Welsh Government	(e.g.) Business Wales, Data Cymru (formerly Data Unit Wales), Digital Communities Wales, Institute of Welsh Affairs (IWA), Public Policy Institute for Wales (PPIW), National Assembly Wales (NAW), Nomis (ONS), Ofcom Wales, Wales Audit Office (WAO), Wales Office (WO), Welsh Government (WG).
	Wales Local Government	(e.g.) Pembrokeshire County Council (PCC), Pembrokeshire Town & Community Council (PTCC), Regional Partnership Boards (RPB), Welsh Local Government Association (WLAG).
Industry	International	(e.g.) Fibre to the Home Council Europe (FTTH), International Telecommunication Union (ITU), Organisation for Economic Co-operation & Development (OECD), United Nations (UN), World Economic Forum (WEF).
	UK Broadband & 5G	(e.g.) Bevan Foundation, Beyond Broadband, Broadband Stakeholder Group (BSG), BT Openreach Community Fibre Partnership (CFP), Superfast Cornwall Report, Superfast Cymru, Think Broadband, UK5G.
	Wales Small Business & Rural Affiliates	(e.g.) Centre for Rural Economy (CRE), Digital Communities Wales, Federation of Small Business Wales (FSB), Independent Networks Cooperative Association (INCA), National Farmers Union Cymru (NFU), Rural Business Awards (RBA), Wales Rural Observatory (WRO)*.
Media	International, UK & Welsh Media	(e.g.) BBC Click, BBC News, BBC Wales, Business News Wales, Financial Times, Forbes, Fortune Magazine, ISP Review, The Daily Telegraph, The Telegraph, TM Forum.

***Wales Rural Observatory (WRO) was decommissioned in 2014, but previous research is utilised.*

3.2.2 Search methodology

The literature review was divided into two parts. The primary search focused on the problem area and the keyword search strings used to identify advanced broadband and rural area studies. The secondary search related to the dot.Rural UK (RCUK) broadband studies which identified rural "capital" as a critical success factor for community-led broadband supply and demand implementation. Additional studies, such as the UK Government broadband impact (SQW, 2013) and Superfast Cornwall project (SERIO, 2015), which was the largest single investment of SFBB in a predominantly rural area, identified four-fold capital benefits of SFBB access and use. The four-fold capital benefits revealed economic, environmental, productivity and social impacts for rural communities and microbusinesses (Phippen & Lacohée, 2016; SQW, 2013). Hence, additional concept keyword searches were employed to investigate these areas.

3.2.2.1 Primary problem area keyword search strings

The keyword methodology, summary edit, and selection of the themes are explained in (Appendix C). Keywords were identified and summarised to provide a search strategy for the study (Hart, 2001).

Summary keywords related to the problem area were defined as:

1. Broadband – advanced, digital, fast or high-speed Internet, information communication tech*, ICT, next-generation access, NGA, superfast & ultrafast.
2. Rural – countryside, remote, rural areas.
3. Communities – community, local.
4. Microbusiness – home-based, home*, microbusiness, micro-enterprise, micro* (Please note – "entrepreneur" was removed from the search string because the results were outside the problem area scope – see Appendix C).

3.2.2.2 Secondary "concept" search strings

Additional keyword searches related to concepts identified in the UK rural broadband literature and considered "critical success factors" to rural broadband initiatives were included:

5. Capital – community, human & social capital.

3.2.2.3 Human & social capital edits

It is essential to explain why edits were made within these fields. The "Entrepreneurship & Regional Development" academic field has numerous studies on human & social capital (Baumgartner et al., 2013; Bosworth & Turner, 2018; Müller, 2016). Next generation access (NGA) can promote entrepreneurship for regional development, but the focus of this study is not on how NGA can stimulate entrepreneurship. The focus and scope of this study is how to get an NGA product to a final few rural market. Nevertheless, all of these factors are symbiotic and are discussed below in the cross-disciplinary academic field analysis (Section 3.2.4).

A review therefore of this academic field was required to identify any salient research. However, numerous studies in this field focussed on the entrepreneur's individual motivation, talent and overall business skills required to become a successful entrepreneur (e.g. opportunity exploitation & so forth) (Huggins, Prokop, & Thompson, 2017; Korsgaard, Müller, & Hanne Wittorff, 2015; Moyes, Ferri, Henderson, & Whittam, 2015). Therefore entrepreneurship studies, in this context, were not relevant to how the supply and demand challenges for deep rural communities could be addressed. Additionally, studies with capitals for rural development, but not specifically broadband, were considered out of scope (Bosworth & Atterton, 2012; Malecki, 1993). This research focuses on advanced broadband supply and demand and identifying other forms of capital that can contribute to achieving the goal of bridging the digital divide. Whilst entrepreneurship is critical to local growth, the above context is out of focus and scope for this study. Nonetheless, the cross-fertilisation and symbiotic nature of these studies is discussed below (Section 3.2.4.1).

To summarise, broadband is viewed as an enabler of economic growth and innovation (Section 1.4). Hence, the scope of this study focusses on how to provide this enabling technology (product) to rural communities and MBs (market) (Section 1.3). Human capital (e.g. IT skills) is a critical success factor (CSF) in broadband implementation, adoption and community-led initiatives (see Section 1.6 & 3.6.7 for the definition of terms). Developing human capital in terms of the digital skills required to implement and exploit advanced broadband is relevant to this study. Thus, research reflecting this focus will be included.

Additionally, social capital is a CSF for implementation, adoption and community-led initiatives (Section 1.6). In this research context, social capital is required off-line, because trust, relationships and networks facilitate supply and demand implementation. Studies focusing on how social capital is developed on-line is not the focus of this study (e.g. the use of Internet social networking for job searches or marketing activities) (Granovetter, 1973, 1983).

Furthermore, studies such as Chen (2013) discuss the implications of social capital for the digital divide, but the author defines the digital divide by socioeconomic status and how bridging (weak-tie analysis) and bonding social capital (strong-tie analysis) can help or inspire people to get online (access) and how to make more use of the Internet once online. It is not about the digital divide regarding supply and demand in the final few and hard to reach rural areas. Similarly, a literature review (Yang, Lee, & Kurnia, 2009) on social capital in ICT research reviews articles from 1996 – 2007 and identifies the impact of ICT on building social capital (dependent variable) and the effects of social capital on the development or use of ICT (independent variable). The authors (2009) divide the studies into individual and collective categories and the impact of ICT (e.g. connecting & changing social capital) and the individual and collective effects (e.g. influencing & enabling social capital) has on organisations, civic engagement (e.g. positive or negative) and so forth. The authors (2009) make future recommendations for more ICT and social capital studies in rural areas and new methods outside of the predominant quantitative studies that have dominated this field. To reiterate, this thesis focus is how to bridge the digital divide. Henceforth, previous ICT and social capital research, as described above, that does not focus on how to reach the final few will be excluded.

Nonetheless, off-line social capital engagement in supply and demand ecosystems in how to reach the final few is relevant to this study. Thus, research reflecting this focus will be included.

3.2.2.4 Innovation Analysis

To investigate new and innovative alternatives to ICT supply and demand (OBJ3, Section 1.2) and provide an alternative lens to investigate the persisting problem area (Section 1.5), a review of the Innovation Management (IM) literature was considered to be appropriate. This was because this thesis discusses innovation opportunities that

are directly tied to the Internet (Section 1.3 & 2.2.6). Moreover, the academic field of IM is a direct result of information communication technologies (ICT) which makes it a relevant supplementary field of inquiry. Therefore, prominent authors and journals were selected to provide an overview of the IM field and identify relevant concepts which are included in (Section 3.3 & 3.7). The list of IM journals is found in (Appendix B).

After an extensive review, (n=57) articles were identified of being within the scope, of which the following were relevant to introduce the field for innovation analysis. The concepts of open innovation (e.g. looking outside the box for solutions), co-creation or user innovation (e.g. engaging citizens/users to resolve problems) and multi-stakeholder engagement for ICT resolution were relevant to this inquiry. Moreover, these concepts can be viewed as human & social capital engagement (e.g. skills & relationship networks) which are CSFs for rural broadband and the theoretical underpinning of this thesis. The core focus of this research is rural broadband. The IM analysis is supplementary to the rural broadband literature. Hence, IM articles selected focused on prominent authors and summarised in each area. This section therefore concentrates on the rural broadband literature review (OBJ1A-C & OBJ2A-C).

3.2.2.5 Summary of keyword themes

In summary, five themes were identified to search the databases. A matrix on the variants used are summarised in the Table (3.4)

Table 3.4 Summary of theme matrix used for database search

Themes	*Broadband*	*Rural*	*Community*	*Microbusiness*	*Capital*
Broadband		✓	✓	✓	✓
Rural	**X**		✓	✓	✓
Community	**X**	**X**		*Not relevant*	✓
Microbusiness	**X**	**X**	**X**		✓
Capital	**X**	**X**	**X**	**X**	

3.2.2.6 Databases

Databases used to search the literature were Business Source Complete (EBSCO), Scopus (Elsevier) and ABI/INFORM (ProQuest). Google Scholar was used as a supplementary database to search for studies that were not found in the business management databases.

3.2.2.7 Peer-Reviewed Journals

The Academic Journal Guide from the Chartered Associated Business School (ABS) was used to identify relevant peer-reviewed journals (Association of Business Schools, 2018). This list is based on journals of established quality and reputation. The search aimed to identify primary journals, authors, and develop a timeline relevant to the field. ABS Journals summary can be found in (Appendix B, Table B.1).

3.2.2.8 Search process

Advanced searches using abstract and title, with the inclusion and exclusion criteria listed above, were used across the databases. The same search string used in different databases could reveal different results. For example, EBSCO "broadband & rural areas" identified articles primarily in publications such as *Telecommunications Policy* and *Government Information Quarterly*, whereas the same search string used in Scopus identified articles in *Journal of Rural Studies* and *Sociologia Ruralis*.

The number of variations and potential combinations available in the search strings made the searches challenging. For example, the "broadband" search contains 11 keywords, while the "rural, community & microbusiness" search contains nine; therefore, the potential search strings can total 99 across four databases, and this does not include the "capital" search. Nevertheless, every effort was made to mix the variations as not to overlook potential studies, but inevitably studies have been missed (Smallbone & Quinton, 2011).

The duplication of results confirmed the best search strings, but alternative combinations were trialled to broaden the scope and identify studies that might contribute. Certain search strings, such as "microbusiness, rural & capital" located articles within the "Entrepreneurship and Regional Studies" academic domain, but the entrepreneurial capital studies, as described above in the human & social capital edits,

were considered out of scope. Thus, the keyword “entrepreneur” was removed from the search string (Appendix C).

3.2.2.9 Editing process

The editing process utilised the advanced search edits within the databases, except for Google Scholar. Google Scholar does not have the same functionality as the business management databases and therefore made the final edits more difficult. As explained, each database can produce varying results. EBSCO, ProQuest and Scopus used the thesaurus, subject, publication and geography edit to exclude large amounts of non-relevant studies. Google Scholar was used as a final check to identify any additional studies.

1. First edit – Inclusion/exclusion criteria as above; date range, language, peer-reviewed.
2. Second edit – Thesaurus edit – using criteria as above.
3. Third edit – Subject edit – relevant to the problem area and keywords.
4. Fourth edit – Publication edit – focusing primarily on ABS rated as above.
5. Fifth edit – Geography edit – removing studies from developing or excluded geographic areas.
6. Sixth edit - Abstract edit – identifying exclusion criteria and studies not relevant to the problem area.
7. Seventh edit – saved to EndNote – duplicates removed.

The final abstract edits included exclusion edits (e.g. noting why & the number of articles rejected), inclusion edits (e.g. noting why & the number of articles), and duplication edits (e.g. the number of articles removed)**.** An example of the search string edit is provided in (Appendix D).

3.2.3 Summary of search results

Secondary grey literature was reviewed from governmental, industry, media reports (Table 3.3), including Welsh economy academic literature totalling (n=218). Academic articles reviewed for rural broadband studies were categorised into four preliminary areas totalling (n=97). The following is a breakdown per category:

1. Community-led rural broadband studies – UK, EU, Canada, Australia, New Zealand and USA, plus China and Peru (n = 21). Four studies are in the UK and two are RCUK funded. Seven studies are in the Netherlands, attributed to a predominant author in this field, Koen Salemink. Four studies are in the USA, two in Canada and two in Australia. Two additionally relevant rural broadband studies from China and Peru.
2. Rural broadband supply and demand studies – UK (n = 34).
   Over half of the UK studies (20) have been generated by dot.Rural (RCUK) funding at the University of Aberdeen.
3. Rural broadband supply and demand studies – EU, Canada, Australia, NZ and USA (n = 34).
4. Recent FTTH, UFBB, and NGA studies have come from UK/USA, EU, Canada, Australia and New Zealand (n = 8). Undoubtedly, more studies will be emerging in 2019 and beyond due to the government push towards Industry 4.0 and NGA technologies.

A summary of the rural broadband research methodologies, across the four areas, are presented in the following (Table 3.5).

Table 3.5 Summary of rural broadband academic journals used for analysis

Area	*Qualitative*	*Mixed or multi-method*	*Quantitative*	*Conceptual, synthesis or literature review*	*TOTAL*
1. Community-led rural broadband studies – advanced western nations	15	2	1	3	21
2. Rural broadband supply and demand studies – UK	16	7	6	5	34
3. Rural broadband supply and demand studies – EU, USA, Canada, Australia, NZ	7	3	20 - predominantly USA	4	34
4. Recent FTTH, NGA and UFBB studies – advanced western nations	5	1	1	1	8
TOTALS	43	13	28	13	97

In summary, a breakdown of methodological inquiry for rural broadband studies in advanced western nations equates to qualitative studies (44%), quantitative (30%), mixed or multi-method and conceptual or literature review (14%) respectively. Percentages rounded to the nearest decimal. Henceforth, more mixed or multi-method studies and conceptual studies would benefit the field.

3.2.3.1 Refined analysis using NVivo 12

To further analyse the results, QSR NVivo 12 was used to code the literature. The iterations developed into four phases:

i. Phase 1 – broad categories: importing from Endnote the four broad categories (e.g. community-led, advanced rural supply & demand, and recent FTTH, UFBB & NGA studies).
ii. Phase 2 – refining details: once coding of abstracts and findings began, refining the broad categories required re-coding and removal of studies not deemed fully relevant to answering the RQs.
iii. Phase 3 – correcting: as a result of re-coding and removal of studies; re-organising the studies into more relevant categories was required (e.g. in-between supply & demand studies were identified).
iv. Phase 4 – reviewing: after each section of literature was completed, reviewing the categories, coding and groupings was required for accuracy.

As a result of the NVivo coding analysis, the revised totals and categories for rural broadband studies will be detailed in the literature review (Sections 3.5 & 3.6).

3.2.3.2 Summary analysis of primary journals for rural broadband studies

A snapshot of the number of articles used from the various journal publications and related country studies are summarised in (Appendix B, Table B2). The greatest number of articles came from *Telecommunications Policy* (n = 21) and *Journal of Rural Studies* (n = 15). The ABS academic field categories summarised in (Appendix B, Table B2) show the range of publications across various domains. Journals not ranked by ABS reflect the multi-disciplinary field of inquiry. The eclectic mix of rural broadband studies is reflected in the following academic field analysis (Section 3.2.4).

3.2.4 Academic field analysis relating to "rural"

Rural studies are not a highly cited field of research compared to other research fields such as innovation management. For example, Mark Shucksmith (UK scholar in rural studies) citations are in the hundreds, whereas Henry Chesbrough or David Teece (US scholars in innovation studies) citations are in the tens of thousands. Rural broadband study citations, as a sub-set area, are often in the low hundreds, despite the potential impact of technology innovation. Ironically, the "digital divide" topic areas have high citation counts, especially if the focus is bridging the gap for developing nations or the potential of ICT to alleviate poverty (ICT4D). Citations in the areas of economic and sociology scholarship, particularly in the field of human & social capital, are in the tens of thousands. Most notably because of Nobel Prize scholars, such as Theodore Schultz and Gary Becker (human capital), and the impact these theories have had on economic, social, political and educational development.

3.2.4.1 Cross-disciplinary academic field

Rural studies or rural area research domains are cross and multi-disciplinary and have specific sub-domains that focus on regional development, mainly from an economic, geographic, political, psychology or sociological viewpoints (Salemink et al., 2017b). Entrepreneurship is heralded as critical for regional development; hence, economists, sociologists and psychologists are interested in how to promote entrepreneurship and economic growth in rural or localised domains (Baumgartner et al., 2013; Müller, 2016). As explained in the search methodology (Section 3.2.2) the focus of this research is on how to get a "product" to a final few and hard to reach "market". Ultimately, providing rural broadband or NGA services, to a final few and hard to reach rural market can encourage entrepreneurship and regional development; hence, the cross-fertilisation of these domains is inevitable.

Previous research in regional development, from economist viewpoints, focused on economic growth models (Müller, 2016; Terluin, 2003). For example, is it more effective for governments (national or local) to incite commercial businesses to relocate manufacturing into rural areas to promote economic growth and jobs for these regions (e.g. exogenous economic growth model) or is it better to "home-grow" regional development by providing financial and business development support to promote localized entrepreneurship (e.g. endogenous economic growth model).

Terluin (2003) provides a critical analysis of the different economic growth models and approaches used to develop rural areas in advanced countries. Evidence from 18 case studies in the EU, revealed mixed exogenous/endogenous approaches (e.g. interlocking internal & external networks in the face of globalisation), and endogenous approaches (e.g. the community-led development theory & Bryden's theory on developing competitive advantage with fixed local capital) are empirically supported. The author concludes that the value of local capacity (e.g. human capital, skills & tacit knowledge), and the strength of internal and external networks (e.g. social capital) relate to non-agricultural economic growth. Conversely, if regions have low value on local capital and weak networks, employment can stagnate. A summary of Terluin (2003) critical analysis of rural growth models relevant to this study is provided in (Table 3.6).

Table 3.6 Summary of rural economic growth models and approaches (adapted from Terluin (2003, p. 333).

Rural economic growth models		Local economic growth theories	Subsidiary local rural theories	Relevance to this study
Exogenous economic growth model "Outside in" & top-down approach	→	Pure agglomeration models – place specific.	Growth pole theory (e.g. move urban manufacturing to specific place)	No – this is a local internal & external stakeholder approach, not an outside in top-down approach.
Endogenous economic growth model "Inside out" & bottom-up approach	→	Local milieu (LM) models – place specific with local environmental factors (e.g. people, physical & events).	Identified three specific LM models: 1.Community-led rural development theory* – self-help model. 2. Bryden's theory* – immobile resources: 4 types – cultural, environmental, social & local (tacit) knowledge capital. 3. Creative Destruction Model – tourism & heritage site development.	Partially – concepts of self-help, supporting local community development & developing local capital for competitive advantage, but this research is not only an "inside out" bottom-up approach.

Mixed exo/endogenous economic growth model "Both" – internal & external forces working together. Bottom-up partnership.	→	Territorial innovation models – Local milieu (LM) model *plus* the diffusion of innovation.		Yes – this thesis is about internal & external engagement with NGA technologies.

**Terluin (2003, p.333) cites Murray & Dunn's 1993 Community Development theory & Bryden's (1998) theory.*

Terluin (2003) makes six recommendations to stimulate employment and economic growth in rural regions: think globally and act locally (e.g. vision to engage as globalisation changes rural landscapes). Improve local skills, knowledge and attitudes (e.g. human capital). Strengthen the cooperation of internal and external networks (e.g. social capital). Maintain balance with external networks to ensure local actors' benefit (e.g. mixed exogenous-endogenous development). Adjust administrative structures (e.g. links to local & national government) and use a comprehensive territorial development plan (e.g. SWOT analysis - strengths, opportunities, threats & weaknesses) (p. 342). These results set an important premise for exploration in this thesis. For example, the value and strength of human & social capital in local rural areas are a contributing force to the implementation and exploitation of innovation (e.g. NGA). This, in turn, can have an economic impact on the area, provided the labour and capital are present (Terluin, 2003, p. 342).

Furthermore, recent community-led rural broadband studies are attempting to incorporate economic and sociology theories. Salemink & Strijker (2016) and neo-endogenous growth models (NED) combine both endogenous and exogenous forces to promote rural development. Numerous RCUK researchers are utilizing resilience theory as a framework for rural broadband studies (Roberts et al., 2017a; Roberts, Beel, Philip, & Townsend, 2017b). More specifically, Ashmore et al. (2017) utilised resilience theory to identify if superfast broadband (SFBB) has had any influence making rural communities and individuals more resilient and reduce the "out-migration" of rural residents to urban centres in search of work and opportunity. Other rural broadband demand-side studies have utilised diffusion of innovation theories (Alam, Erdiaw-Kwasie, Shahiduzzaman, & Ryan, 2018; Salemink et al., 2017b), but

overall, rural broadband studies are not as robust yet on theory development as compared to other domains (e.g. economics, sociology or business management).

This research therefore aims to take a wider perspective of this field of potential opportunity and cross-fertilise across the domains. The following (Figure 3.1) provides a snapshot summary of the differences across rural area studies and the focus of this study on business management, although the research field can be viewed across the various sub-sets. The inherent cross-fertilisation and multi-disciplinary context of management, economics, sociology and so forth will be a main construct in this thesis. Moreover, the highly cited field of IM studies equally promotes the necessity of not isolating economics from management or sociology but ensuring academic rigour is maintained by incorporating the relevant disciplines (Shafique, 2013).

Figure 3.1 Cross & multi-disciplinary nature of rural studies

Rural Areas/ Studies	**Regional Development/ Entrepreneurship**	**Business Management**
Changing face of rural	*Economic growth theories (Local Milieu & NED)*	*Products to final few markets*
Farming/subsidies	*Entrepreneurship studies (MBs)*	*ICT Innovation*
New/green energy		*Innovation Management (open innovation, co-creation, multi-stakeholder)*
Out-migration-depopulation		
Tourism		

**Adapted from: Cross & multi-disciplinary nature of rural studies (Shucksmith et al., 2012) regional development & entrepreneurship (Müller, 2016; Terluin, 2003), innovation business management studies (Shafique, 2013; Tidd & Bessant, 2009).*

The advent of Industry 4.0 requires highly skilled human & social capital, which could lead to a revival of economic reform if embraced (Jones & Henderson, 2019). This economic revival could be true of Wales. Wales has invested heavily in growing its "knowledge economy & productivity" by focusing on educating its population for competitive advantage (Swansea Bay City Deal, n.d; White et al., 2019). For example, the introduction of the Computational Foundry and the Advanced Manufacturing Engineering facilities at Swansea University, South Wales, is a testament to the nations determination to grow its technology skills base and compete again in the global arena (Swansea University, 2019). Hence, this case study focus on how multiple rural

stakeholders can engage in the arrival of Industry 4.0 and NGA services may prove fruitful for economic, as well as individual, political and social celebration for the nation.

3.2.4.2 Positioning of this research – Product to rural market analysis

There are four primary studies that have influenced this research. One is Ashmore (2015) whose thesis investigated how demand-driven community-led initiatives achieved, or failed, in getting a SFBB "product to market" and the resultant resilience impact SFBB did or did not have on the rural communities. The second is Gerli & Whalley (2018) analysis of a supply-driven public-private partnership (PPP) rural "product to market" strategy and the resultant success and failure factors of the initiative. The third is Wallace et al. (2015) analysis of community-led "product to market" strategies in various deep rural geographies and the resultant capital analysis involved in the success or failure of these initiatives. The fourth involves Salemink & Strijker's (2016, 2017, 2018) rural neo-endogenous case study research, but much of the research was conducted in the Netherlands and at a macro-level because the researcher's had access to governmental data (see resultant eight-stage model, Section 3.5.1.1, Table 3.9).

The principal methodology for these rural "product to market" investigations were qualitative case studies in order to ascertain what the key stakeholders' motivations and challenges were in starting and/or completing these projects. This thesis will seek to fill the research gap identified by Salemink, Bosworth & Strijker (2017b) with a supply and demand study at the local level (see Section 3.4.1).

3.2.4.3 Recognition of cultural influence

One final observation. Shucksmith et al. (2012) summarise the cultural and political differences between USA, UK and EU rural policy attitudes. Salemink & Bosworth (2014, June) equally identify the differences between the "socialism & negotiation" attitudes in the Netherlands versus the "sense of fairness" attitudes prevalent in the UK approach to rural broadband implementation. The different attitudes towards national policymaking can be attributed to its cultural inheritance. For example, the USA celebrates the free-market economy and discourages government intervention unless necessary. The EU favours a more socialist approach and desires government intervention. The UK seems to sit between these two positions and aims to engage the

free market, but with assistance from the government as and when required (Bosworth & Salemink, 2014, June; Shucksmith et al., 2012). It is useful to consider the potential cultural biases that may be prevalent in the studies.

In summary, the search for rural broadband studies in advanced western nations revealed a cross and multi-disciplinary academic field. Qualitative and quantitative studies are almost evenly mixed (40-30%, respectively). Mixed and multi-method, and conceptual and literature reviews contribute evenly (14%), but more research in these areas is warranted (Table 3.5). The search review does not include a summary analysis of capital literature as a supplementary concept, but the results are provided in (Appendix C). The potential of Industry 4.0 and the advanced human & social capital skills required to capitalise on this new wave of innovation could bring an economic revival to advanced western nations rural communities (European Commission, 2017; NAW, 2018). Case studies are the primary methodology when investigating community-led initiatives (ADD REFS). Cultural biases exist between advanced western nations and their approach to policy and government intervention (Beltrán, 2014; Roberts et al., 2017a; Whitacre, 2010). Prior to reviewing the rural broadband studies, a short historical context of telecommunications and ICT innovation will be presented in the following (Section 3.3).

3.3 ICT innovation & the digital age

This section introduces the historical context required to set the foundation of the study. The short history details the relevant milestones and major developments leading up to today's digital innovation and the challenges and opportunities to be explored in this thesis.

3.3.1 A short history of telecommunications - 1750-2000

The history of worldwide telecommunications (Huurdeman, 2003) is an engineer's view of the chronology of ICT innovation which leads to today's global network. The chronology starts before 1800 with the optical telegraph, even though communications can be traced back to the earliest of civilisations. Most communication innovation came as a need to warn others of impending danger (de Leeuw & Bergstra, 2007). Throughout the centuries, these innovations often began as military means of communication and then diffused for commercial use (Singer & Friedman, 2014).

Some of the earliest methods of notifying others of impending danger or attack came from smoke signals. Smoke signals can be traced back to Greek, Roman, Native Indian and British times (e.g. "Beacon Hills" are named after these signalling sites), but as technology evolved so did the means of less obvious communication systems (de Leeuw & Bergstra, 2007). Huurdeman (2003) limits his research to the 1932 International Telegraph Union (ITU) definition of telecommunications as the start of visual (semaphore) signalling (e.g. arms, flags, light or board signalling). This definition implies that telecommunications started during the French Revolution when the first optical telegraph system across the country to thwart the British. The author states, *"the optical telegraph was the first functional telecommunications device to be used successfully until succeeded by a superior solution: the electrical telegraph. Thus, it is that the creator of the optical telegraph, Claude Chappe, deserves to be called the 'father of telecommunications' (p. 17)".*

Huurdeman goes on to detail the chronological development of ICT and telecommunication innovation from 1800-1850 (e.g., optical telegraph, electrical telegraphy); 1850-1900 (e.g., open-wire lines, underground & submarine cables, Morse code, telephone, automated telephone switching, radio transmission); 1900-1950 (e.g., worldwide telephone penetration, high-frequency radio transmission, copper-line transmission, cryptography); 1950-2000 (e.g., semiconductor era, digitalisation, new telecommunication networks, satellite transmission, optical fibre transmission, electronic switching, cellular radio, digital cellular radio) to our present-day multi-media era (e.g., combination of different content forms such as text, audio, images, animation, video & interactive content). The importance of broadband is that it is a telecommunications medium which can cope with the large volumes of data required for multimedia applications (Dutton & Peltu, 1996, p. glossary).

The origins of the Internet are attributed to when the USA Government was caught off-guard by the launch of the Russian Sputnik satellite in 1957. The USA Government quickly instituted the Department of Defence Advanced Research Project Agency (DARPA) to combat the threat of Russian space innovation (Castells, 2010; Huurdeman, 2003; Singer & Friedman, 2014). According to Castells (2010), on September 1, 1969 the first *computer network* went online, named ARPANET after its powerful sponsor, with the first four nodes of the network established at the Stanford

Research Institute, University of California Los Angeles, University of California, Santa Barbara, and University of Utah (p. 45). The research began with American Universities but was eventually released for commercial use circa 1994 (Singer & Friedman, 2014).

Prior to the Internet, some significant discoveries preceded the event. After World War II, there were substantial breakthroughs in electronics**.** The discovery of the transistor in 1947 (also known as semiconductor or "chip") awarded William B. Shockley, John Bardeen, Walter H. Brattain from Bell Laboratories with the Nobel Prize for Physics in 1956 (Nobel Prize, 1956). The subsequent diffusion of microelectronics, initiated by Intel, with the microprocessor (or computer on a chip) in 1971, set the scene for the information age (Castells, 2010; Huurdeman, 2003). Castells (2010) summarises that the combination of these two technologies, telecommunications and computer networking technologies, made possible by the *"combination of node technologies (electronic switches and routers) and new linkages (transmission technologies)"*(p. 44) gave rise to the "network society". The *node* is the ability to connect the network. The *transmission* is the way information is sent across the networks (e.g. radio spectrums, direct satellite broadcasting, microwaves, & digital cellular telephony).

Finally, circa 1990, Tim Berners-Lee at CERN, the European Organization for Nuclear Research in Switzerland, developed the Hypertext Transfer Protocol (HTTP) with a system to identify linked documents (URLs) (Singer & Friedman, 2014). HTTP is defined as a "*technical protocol that defines how applications ask for and delivers content"* (p. 296). This innovation made the Internet easy to read and search for everyday users, which provided the rapid global proliferation and introduction to the "information age".

3.3.2 The post office

Preceding the USA and European inventions, multitudes of telecommunication innovations evolved out of the post office in the UK. The post office was the national infrastructure which originally provided hand-delivered written communications, to wire transferred communications (e.g. the telegraph), and eventually radio wave communications (BT, 2015). British Telecommunications (BT) evolved out of the post office, and is the oldest telecommunications company in the world, established in

1846. The post office and BT are responsible for many "firsts" in the industry (BT, 2015). For example, the first telegraph line (1839), the first transatlantic call (1926), the first car radiophone (1959), the first commercial optical fibre link (1984) and the world's first optical super-channel fibre link (2014). According to Tim Whitley, Managing Director of Research & Innovation at BT's Adastral Park, it has been 170 years since Cooke & Wheatstone filed the first patent (1836) for the electrical five-needle telegraph, which started operations on the telegraph line (1839) and eventually set the stage for global communications (BT, 2015; Huurdeman, 2003). These telecommunication innovations and thousands more, built one upon the other and have transformed the world into the worldwide web, or the horizontal global communication system, as it is known today. Additionally, postcodes are used to identify properties and broadband speeds and are, therefore, a significant correlation to be used throughout this study.

3.3.3 The rise of the network society – 1970-2000

Castells (1997) explores some of the developments that have helped shape society with the creation of the Internet and how managing communication has changed because of microelectronic-based communication technology (e.g. the Internet & mobile phones). Castells (2010) shapes his theory between 1970-2000 because the creation and formation of the Internet are what has allowed the network society to evolve. The author explains *"the Information Technology Revolution did not create the network society, but without IT, the Network Society would not exist"* (p. 7).

In Castell's (1997) seminal work on the information age, the author explains how the post-industrial age social structures, from the bureaucratic and institutional hierarchy, have changed in the face of the information technology revolution to decentralised networks. Castells defines the network as a set of integrated nodes, borrowing the technical terms from the Internet but applying it to the new social structures. A node is a point where a curve intersects itself. Castells (2010) explains, for example, media networks intersect with television studios, to news outlets, to our mobile phones to provide news content. The author defines networks as open structures, and by integrating new nodes, the expansion is limitless (p. 501). The author argues the new social networks are good at managing complexity and are innovative

and dynamic, able to adapt more quickly to changing social conditions than the previous "control" of information through old bureaucratic institutions.

The author makes use of the term *network society* to describe how our social structures have adapted to the information age (Castells, 2010). According to Castells (1997), this new global access networking system has affected how societies operate. For example, workers are outsourced and subcontracted. Communication becomes global and customised. Individuals and territories who are switched on are more valuable than those who are switched off (p. 15). Thus, resulting in a digital divide between countries who are connected versus those who fall behind.

3.3.4 The work from anywhere phenomenon

Innovation in itself is a repeating phenomenon (Fagerberg, 2004; Trott & Hartmann, 2009). Hurrdeman (2003) states that after 50 years of research, some scientists rank the invention of the transistor at the same level of human innovation as the invention of the wheel or the control of fire (p. 365). Moreover, life-changing inventions can be traced back to the dawn of civilisation and are evident in every generation.

Schumpeter (1959), also known as the "prophet of innovation", describes how entrepreneurial activity utilises the latest technical innovations, to create novel products and services to gain a strategic advantage (Abrams, 2007). This constant search for something new, in every generation, will ultimately overcome the old ways of doing business and create a repeating "creative destruction" in economic cycles. Grant Leboff, CEO of Sticky Marketing, states we are in the middle of a "communications earthquake", whereby the "old" communication structures are collapsing, but the dust has not yet settled. The old forms of communication were controlled by print or media conglomerates, who screened and edited what could be published in newspapers, magazines, radio, and television (Leboff, 2011). The introduction of YouTube (2005), Facebook (2006) and the iPhone (2007) has liberated communications and interactions worldwide. People can create content and publish, un-hindered and un-restricted across numerous Internet platforms. Control of information is no longer in the hands of a few, but the many. Facebook reached two billion users in June 2017 (Chaykowski, 2017, June 27), and the iPhone is approaching one trillion in sales (Reisinger, 2017, January 12). Innovations in the last decade have given rise to the "work from anywhere" phenomenon and enabling users to work in

ways not previously imagined. For example, microbusinesses (0-9) employees can run a business on a smartphone. Cloud computing and new subscription-based software packages, like Xero financial accounting software, allow businesses to check bank balances, pay staff, issue invoices, record expenses and pay taxes from one piece of software (Welsh Government, 2019). These subscription-based products and services, offer low-cost entries into business, provided broadband and mobile connections are available (Cardiff University, 2019; Welsh Government, 2019).

3.3.5 The digital age – A new context

As a result of ICT innovation, another critical assessment is how the context has changed which is summarised succinctly by Bessant (2015). The author argues that we need to take a step back to see that the world has changed. The world is now a system; it is networked and global (Bessant, 2015). Strands of knowledge exist inside and outside of businesses and weaving these things together creates value. Bessant (2015) describes *open innovation* as a term to describe the problem. It is a revolution in thinking and describes the *networks* and *knowledge flows* required to succeed in this new *ecosystem*. Bessant argues how innovation flowed back in the 16th century in Florence and was always a *multiplayer* game. The author compares it to the 20th century when knowledge became static and focussed on accumulation, ownership and then diffusion, but the 21st century is different. Today, it is about the flow of knowledge. It is about knowledge trading. It is *dynamic* and not static. It is about connectivity and joining the dots. It is no longer exclusive, but inclusive and businesses need to adapt to this new landscape. Bessant (2015) continues to describe how *collaborations* are changing because of ICT. These are all core concepts for this thesis.

Furthermore, Bessant (2015) explains the context has changed and "new" roles, such as gatekeepers, knowledge brokers, bridges and networks have emerged. The role of the gatekeeper is not a new concept, because Thomas Allen introduced it from MIT in the 1970s and the value these people play in the pollination of new ideas within business clusters and ecosystems (Allen & Cohen, 1969). However, the context in which these roles now operate is in a global, networked, eco-system and new ways of managing this new world are being developed (Tidd & Bessant, p. 122). The "value" of this human & social capital is what drives the information age, the new knowledge

economy, and the forthcoming digital age (Díaz Andrade & Urquhart, 2009; Roche & Jakub, 2017).

3.3.6 The digital divide

Since the 1990s, the fastest diffusing technology in the history of communication is wireless communication and the mobile telephone. Castells (2010) summarises, in 1991, there were 16 million wireless phone subscriptions in the world; by 2008, it surpassed 3.4 billion (p. 1974 preface). Huurdeman (2003) states, as of the year 2000, there were 740 million mobile telephones and 367 million Internet users worldwide (p. 605). In 2015, the International Telegraph Union (ITU) reported Internet users surpassed 3.2 billion and mobile cellular subscriptions exceeded 7 billion (Zhao, 2015, August 25).

A summary of global statistics by the International Telecommunications Union (ITU) is shown in (Table 3.7). Fixed broadband subscriptions have tripled, and mobile broadband subscriptions have exploded in growth. The growth statistics can be attributed to the introduction of Facebook (2006), the iPhone (2007), and the "work from anywhere" phenomenon.

Table 3.7 International Telecommunications Union (ITU) Global Statistics 2017 (ITU, 2017)

ICT Key Indicators	2007 (in millions)	2017 (in millions)
Fixed telephone subscriptions (world)	1243	972 (declining trend)
Mobile cellular telephone subscriptions	3,368	7,740 (doubled)
Fixed broadband subscriptions	346	979 (tripled)
Active mobile broadband subscriptions	268	4,220 (explosive growth)

This explosive growth and global connectivity are multiplying digital communications, but not everyone has access. International organisations, such as the International Telegraph Union (ITU), the Organisation for Economic Co-operation and Development (OECD), the United Nations (UN) and the World Economic Forum

(WEF) have all published reports on the importance of bridging the digital divide (ITU, 2013; OECD, 2018; The Boston Consulting Group, 2016). Recent research by the UN and the WEF state over four billion people are without the Internet because they live in hard-to-reach rural areas (The Boston Consulting Group, 2016; UN, 2016).

Recent European and UK studies have criticised western "neo-liberal" governments (e.g. free-market economies) and the market "failure" to provide broadband in rural areas and encourage more government intervention (Ashmore et al., 2017; Salemink et al., 2017a). However, comparative research reveals how Japanese and Korean governments, who are global leaders in full-fibre implementation, played a marginal role (Vicente & Gil-de-Bernabé, 2010). Instead of government-controlled implementation, the Japanese and Korean governments enabled the private sector with favourable regulatory environments, supportive loans, subsidy incentives, and tax regimes that fostered investment and healthy competition (p. 821).

In addition to varying governmental policies, complexities in delivering community-led broadband schemes in hard to reach rural areas are detailed in the UK market test-pilot schemes (DCMS, 2016a). Seven pilot schemes were commissioned to trial different technologies, financing and operational models in remote rural locations. One pilot, Cybermoor, described the challenges communities face when organising full-fibre networks (Cybermoor, 2016). Multiple challenges must be overcome throughout the different deployment stages from pre-planning, funding, bidding, planning, building, selling and operational phases. Steep technical learning curves compound these challenges for communities who operate predominantly on a volunteer basis (B4RN, 2011; Cybermoor, 2016). These complexity findings are validated by research conducted in the Netherlands (Salemink & Strijker, 2018) and will be explored further in this thesis.

In summary, over the past two decades, the world has witnessed phenomenal digital transformation. The recent global ambitions of Industry 4.0 (Lasi et al., 2014), the UK Government future of telecommunications project (DCMS, 2018b), and the Fibre to the Home International Councils (FTTH, 2004) will continue to drive the NGA supply and demand agenda. The President of the Fibre to the Home Council Europe, Ronan

Kelly, states "*our mission is to push for fibre connectivity to 'Connect Everyone and Everything, Everywhere'.*" (Jackson, 2018, February 14). The digital divide between increasingly faster broadband speeds, costs and services in urban areas continue to outpace rural areas (Gerli & Whalley, 2018; Ofcom, 2018b). Global governments and institutions are working to bridge the digital divide, but national and local complexities exist (The Boston Consulting Group, 2016). The digital divide is therefore a persisting problem area unless more solutions are found to bridge the gap (DCMS, 2016a; INCA, 2012).

3.4 Foundation of the literature review

The following sections review the rural broadband literature with a focus on how to reach the "final few" rural areas (Section 3.5 & 3.6). Prior to reviewing the literature, an explanation for the foundation of the literature review is required. As explained in the research context (Section 2.3.6.3) a 6-week Swansea iLab Microbusiness pilot project for BT started the process as a follow-on from the Superfast Cornwall studies, using these as the methodological precedent in so far as they focussed on microbusinesses (MBs) rather than the full SME population (Section 1.3). The following two sections detail the starting points for this thesis and subsequent literature review.

3.4.1 Starting point & research gap

To lay the foundation of the literature review, it is necessary to state the academic precedent for this thesis. There are two primary resources. One is the findings from the Superfast Cornwall reports (Lacohee & Phippen, 2015; Lacohée & Phippen, 2013; Phippen & Lacohée, 2016; SERIO, 2015) and identifying the four-fold environmental, financial, human & social capital benefits SFBB had on rural communities and MBs in a remote rural area (Section 1.4 & 2.3.6.3). The second resource is Salemink, Strijker and Bosworth (2017b) systematic literature review on rural development in the digital age. The authors reviewed 157 articles from 2000-2013 with the aim of extracting lessons from the debate thus far. As with previous rural broadband literature reviews, such as Galloway & Mochrie (2005), the authors organise the findings into connectivity (e.g. supply studies) and inclusion (e.g. demand/people studies) (Salemink et al., 2017b).

The research gap identified by Salemink et al. (2017b) is the need for more localised studies at the community level. The authors argue that macro studies, for supply-side, have taken place at the national or regional level, with policy recommendations, funding options and investment impact of SFBB (Salemink et al., 2017b). Micro studies, for demand-side, have taken place at the individual level, primarily identifying the need for more awareness and skills training to promote adoption and reduce digital and social exclusion. The authors argue the next stage for the rural digital research agenda should include engagement at the community level, to combine both supply and demand (e.g. exogenous and endogenous stakeholders), together, within a local community context (p. 367). This is the research gap this thesis aims to explore.

Notably, this thesis literature review focuses on the last decade of research from 2010-2019 (Section 3.2). Salemink et al. (2017b) systematic review covers 2000-2013. The Research Council UK (RCUK) funded SFBB studies are published after 2013. Thus, the goal of this literature review is not to duplicate previous reviews. Hence, the aim is to utilise the work of Salemink et al. (2017b) as a foundational base, and review more recent, or post-2013, analytical, empirical and theoretical studies in relevance to the research objectives. Analysis of studies prior to these dates will be included if relevant for this review. Salemink et al. (2017) provide a visualised summary of the literature review and the gap for future research that demonstrates the need for combined supply (connectivity research) with demand (inclusion research) into a market-facing, community-based approach (Figure 3.2). For purposes of this thesis, supply and demand terminology will be used in place of connectivity or inclusion.

Figure 3.2 Summary gap in literature review

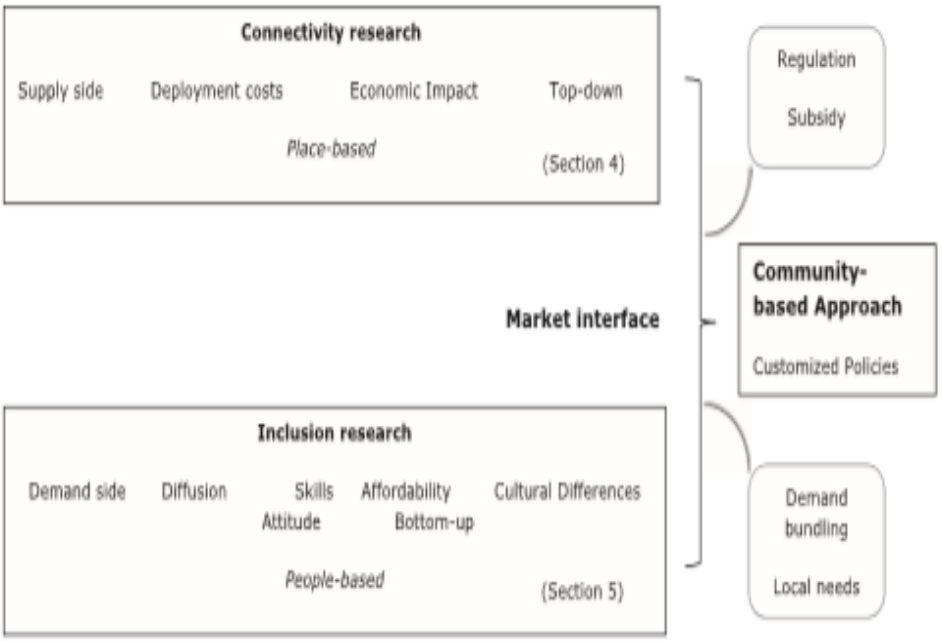


Fig. 1. Combining connectivity and inclusion research to create a community-based approach.

** Taken from Salemink, Strijker & Bosworth (2017) systematic literature review summary & gap for future research (p. 368).*

3.4.2 Starting point for UK rural broadband

As explained in the introduction (Section 1.3) more in-depth rural studies in the UK occurred between 2009-2015 with the UK Research Council Digital Economy (RCUK). RCUK invested over £138 million to explore the transformational impact of digital technologies on communities, culture, the economy and future society and release the hidden "capital" in rural areas (Philip et al., 2015c; RCUK, 2015; UKRI, 2015). Unsurprisingly, a majority of the rural broadband studies (n=18) are RCUK funded research which provides a solid research base into UK SFBB studies.

Moreover, RCUK-funded researchers made frequent use of the term "capital*"* which adds to the theoretical context for this thesis. The authors identified cultural, digital, environmental, financial, human, identity, social and technology capital as assets and benefits to rural communities (Ashmore, Farrington, & Skerratt, 2015; Philip et al., 2017; Roberts & Townsend, 2016; Townsend et al., 2016; Wallace et al., 2015; Wallace et al., 2017).

In summary, in order not to duplicate work, but build on relevant research to answer the research objectives, these studies set a foundation for what follows. The following sections will review the academic research within this context.

3.5 Rural broadband – The "final few" and hard to reach (OBJ1)

Prior to the June 2019 rural gigabit connectivity programmes (RGC), as explained in the introduction (Section 1.4), the rural digital divide literature focused predominantly on three main areas: supply, demand and community-led initiatives. The changing terminology of superfast broadband studies (SFBB), advanced broadband studies (to include UFBB) and NGA (to include FTTH/P & 5G technologies), must be used interchangeably to reflect the unit of analysis during the time of research. Thus, the following literature review analyses the previous studies over the past decade, using the relevant terminologies. Advanced rural broadband studies will be used as a generic term, as and when required, but with the future focus of NGA implementation and investigation.

This section begins with the recent literature on community-led initiatives (Section 3.5.1) and then reviews findings from rural broadband supply and demand studies in the UK, EU, USA, Canada, Australia and New Zealand (Sections 3.5.2). Studies identified as in-between supply and demand are reviewed in (Section 3.5.3). Followed by an evaluation of recent FTTH, NGA and UFBB studies relevant to the topic (Section 3.5.4).

3.5.1 Rural broadband - Community-led initiatives (OBJ1A)

Overall community-led studies identified in the search totalled (n= 21). A summary of NVivo analysed articles included and excluded in this section are provided in (Table 3.8).

Table 3.8 NVivo refined analysis community-led rural broadband studies

Included	*Excluded*
Four studies are in the UK, two of these are funded by RCUK.	One study on community funding support was re-allocated to supply studies (Jackson & Gordon, 2011),
Five studies are in the EU, four attributed to a predominant author in this field Koen Salemink.	Another study was re-allocated to in-between supply and demand studies as the effects of broadband on volunteering and civic engagement (Stern, Adams, & Boase, 2011).
Two studies are in Canada & the USA, and two in Australia.	Four studies were removed because the focus was not on rural broadband or within scope (e.g. ICT4D in Mexico, Internet TV, citizen initiative not related to rural broadband). (Armenta, Serrano, Cabrera, & Conte, 2012; de Haan, Meier, Haartsen, & Strijker, 2018; Ramírez, 2007; Youtie, Shapira, & Laudeman, 2007).
Two studies were included from China & Peru that focus on grassroots leadership, entrepreneurship and ICT diffusion in remote rural regions relevant to this study,	

After further investigation using NVivo to code findings, the remaining studies were separated into three different groups:

i. Rural broadband studies for neo-endogenous development (NED) – (n= 4).
ii. Community-led broadband case studies – local community mobilisation as a reaction to market and governmental failure – (n= 7).
iii. How the community was engaged or strategies to develop intelligent or digitally involved communities – (n= 4).

Thus, the following community-led broadband analysis will be organised into three areas (Section 3.5.1.1 – 3.5.1.3).

3.5.1.1 Rural broadband studies for neo-endogenous development (NED)

Four studies are included in this section. Bosworth and Salemink (2014, June) study investigates community-led broadband as a model for neo-endogenous development (NED). This study is a precursor to later publications and the development of NED over numerous case studies, predominantly in the Netherlands. This first study analysed nine case studies in the UK, and nine in the Netherlands to determine the motivations and arguments used by the Community Action groups (CAGs) and how bottom-up (endogenous) and top-down (exogenous) influences affect results. The authors view CAGs as neo-endogenous actors in the rural development process. Bosworth & Salemink (2014) cite Ray's 2001 definition of NED which involves

linking endogenous local actors, resources and participation to exogenous networks to solicit the resources and assistance required to achieve local goals (p. 1).

The analysis identified critical success factors (CSFs) used to test NED theory. These included the endogenous role of local actors and the communication and organisational skills within the community (e.g. human capital), the level of capital assets and resources available (e.g. financial capital and so forth), network relations (e.g. social capital) and area/place specific (e.g. local milieu economic growth theory as a foundation for NED). The authors found *"the endowment of local community with human capital, as well as with network links to external influences, is important both for the emergence of and participation of CAGS and for their subsequent trajectories" (p. 14).*

Rural broadband NED research continues with three additional studies (Salemink & Strijker, 2016, 2018; Salemink et al., 2017a). The key findings include the complexities and concepts the authors introduce. For example, the endogenous and exogenous actors, the networks, the critical value of human capital, social capital and trust. These concepts are foundational to this thesis.

Salemink & Strijker (2016) develop a useful eight-stage model as an analysis tool that supports rural community stakeholders to understand the varying degrees of engagement throughout the process (p. 784). It is an effective analytical tool to identify the interplay of the bottom-up endogenous, and the top-down exogenous opportunities and pitfalls. These findings are comparable to the BDUK market test pilot case study, Cybermoor "Broadband in a Box", which was an in-depth government pilot case study tasked with presenting the detailed findings of their experience for other communities to use (Cybermoor, 2016; DCMS, 2016a). Nonetheless, the eight-stage model is not a detailed or step-by-step process, but a tool developed to analyse the stages in relation to NED perspectives (Table 3.9).

Table 3.9 The eight-stage model adapted from Salemink & Strijker (2016, p. 784)

Eight-stages	**Bottom-up** Endogenous Actors: *Local communities & actors*	**Top-down** Exogenous Actors: *Regional government or commercial suppliers*	**Critical success factors (CSF)** *CSF & concepts identified relevant to this thesis*
1. Incentive For rural communities or local or regional governments to act.	Bottom up Social capital & organisational skills are required.	Top down Facilitated by local or regional government or local or regional cable company.	In sparse rural areas with little social, intellectual or financial capital, governments are more likely to act as driving force.
2. Familiarisation Rural broadband is technically & financially complex. Steep learning curve for most communities.	Author's state ideal aim for local groups is to own the open network.	Aim for markets is to eventually own the network.	Some initiatives choose to rely on or collaborate with the market player but need to be careful of competing ideals or powerplays.
Stages 1 and 2 are more informal self-organisation. *Stage 3 and above are more formal.*			
3. Inventory of demand Going house to house to discover who wants the service in preparation of applying for funding and/or negotiations	Either endogenous or exogenous actors. Demand bundling to build the *business case* to apply for funds and/or attract investment. Some fail here if no demand.		Awareness of the value of SFBB is critical to demand/adoption.

4. Campaigning Raising awareness of why SFBB is of value to local citizens.	Bottom up Make use of their local knowledge and network, but they need financial support. Endogenous resources are not enough to run a campaign	Top down Launch professional campaigns because they have the required resources and skills. However, they run the risk of 'one size fits all', which does not do justice to local situation - often experience problems in organising a network for accessing local expertise & conducting the campaign.	External parties need local stakeholders. Local social capital is *essential* at this stage, especially for building *trust.*
5. Bundling demand The 75 cases used in study reveal that substantial social capital is required at this stage.	Trust proves to be essential at this stage. Intellectual capital is required to understand why broadband is important. Financial capital is required to afford high fees.		Trust Intellectual (or human capital) Financial capital
6. Tender & Contracting Negotiating the costs.	Legal & financial issues are usually the cause of struggles at this stage.	This stage is often confidential, but local communities need critical skills.	Local actors (human capital) need ICT expertise & contract negotiation skills. Beware of volunteer burnout.
7. Construction & commissioning Building the network.	Local involvement, knowledge & support are significant in the construction stage. Capacities of key people has to develop and/or recruit volunteers who have these capacities.		Market players would benefit from local social capital, trust & expertise.

8. Management & maintenance Ongoing commitment.	It is difficult for local actors to manage and maintain the network as volunteers - would benefit from exit strategy.	The municipality role as facilitator and source of financial support played a leading role in the realisation of this project.	Volunteer burnout is a problem throughout this process.

The eight-stage model serves as an analysis tool to understand the complexities for both bottom-up endogenous local actors, and top-down exogenous external actors. Salemink & Strijker (2016) provide a relevant summary and gap for further research (p. 792):

> *"The key to successful rural broadband initiatives lies in the cooperative interplay between the various stakeholders. To contribute to this knowledge about this interplay, we suggest that research on rural broadband – and rural development more generally – focuses on mutual learning between endogenous and exogenous actors".*

In summary, the authors identify **cooperative interplay** and **mutual learning** amongst various actors and stakeholders are notable keys to successful rural broadband initiatives. The core concepts identified within NED are the internal endogenous actors (e.g. local citizens & entrepreneurs), the external exogenous actors (e.g. market & policy makers), the level of skills, knowledge and capacity of network actors (e.g. human capital) and the value of networks (e.g. social capital). Salemink, Strijker & Bosworth (2017a) summarise that community-led broadband is a multi-faceted, multi-stakeholder (e.g. citizens, governments & market players) and complicated process.

More specifically, Salemink & Strijker (2018) question if this is a good participatory model or a recipe for disaster. Salemink and Strijker (2016) argue citizens and governments need to work together if they are to succeed in completing initiatives (p. 791). The authors caution governments not to frustrate local initiatives and warn *"this could prove fatal, since the current conditions of broadband in remote rural areas does not seem to be feasible without commitment of local citizens and entrepreneurs"* (p. 792). The delicate balance of having the right amounts of financial, local, intellectual and social capital mixed with the sometimes-competing ideals of government and market players needs to be managed for the benefit of all stakeholders.

Therefore, a multi-stakeholder-multi-capital engagement is required for exploration in this thesis.

3.5.1.2 Community-led broadband case studies

Seven studies are included in this section. Local community-led broadband initiatives are a reaction to market and governmental failure, and the following empirical studies identify critical success and failure factors of these initiatives. Four of the following case studies are from the UK (Ashmore, 2015; Ashmore et al., 2017; Gerli & Whalley, 2018; Wallace et al., 2015). A community-led broadband study comparing creative and best practices in Canada and Ireland (Halseth et al., 2019). The China case study confirms how grassroots entrepreneurs can regenerate remote rural communities with facilitating governmental support (Leong et al., 2016). The Peru case study reveals the non-financial value of local leaders, with strong human, institutional and social capital, that assisted the diffusion of ICT knowledge and skills in remote rural communities (Díaz Andrade & Urquhart, 2009).

Wallace et al. (2015) set the foundations of the various business models used by four community-led case studies and the critical success factors (CSFs) and limitations therein. The authors identify five capitals required for success: financial, human, identity, social, and technology capital. Human capital is defined as the leadership required and makes note of the higher education levels of the entrepreneurial leaders (e.g. degrees or higher). All the entrepreneurs mobilised local networks, had high levels of human & social capital, and were respected and trusted by the local community that made it a successful model of community leadership (p. 114). All four community-led case studies were "bottom-up" initiatives started by a local entrepreneur or leader who had the skills to make it happen.

Another significant finding in all the bottom-up initiatives is the grassroots leadership and the support role that government played (Leong et al., 2016; Salemink & Strijker, 2018; Wallace et al., 2015). All the bottom-up case studies reviewed in this section started with the local community and found creative solutions to fit their circumstances by working with external networks (Ashmore et al., 2017; Halseth et al., 2019; Leong et al., 2016). For example, the business models vary from non-profit cooperatives to social enterprises and in one case a for-profit model, which was later sold to the community (Halseth et al., 2019; Wallace et al., 2015). Volunteer labour

and free of charge way leave access (e.g. granting right of way over or under someone's property) reduced costs to the project, but financial capital was solicited through funding applications or through organising shareholdings (Ashmore et al., 2017; Halseth et al., 2019; Wallace et al., 2015).

Community-led broadband initiatives can be said to engage "shared financial capital" (SFC) because funding comes from a variety of different sources, including charitable institutions, the local authority, the local community, regional or national funding and tax incentives (Cybermoor, 2016; Wallace et al., 2015).

3.5.1.2.1 Critical success factors (CSFs)

The CSFs identified in all the case studies are the combination of non-financial capital and shared financial capital (SFC). The non-financial capitals identified include, human, identity, social and technological capital (Wallace et al., 2015). Ashmore et al. (2017) identifies leadership, local digital champions, skills, social capital, word of mouth and trust, plus solidarity against corporate failings or coercion (p. 416). Diaz Andrade & Urquhart (2009) and Leong et al. (2016) demonstrated the value of human, institutional and social capital for ICT diffusion and impact when valuable grassroots leaders are involved.

Wallace et al. (2015) defines identity capital as the strong sense of commitment and loyalty to the location because they chose to live in a remote village (e.g. value of local milieu economic growth). Ashmore et al. (2017) identified a "sense of place" as a strong community tie to support and improve local initiatives.

Technology capital is an unequivocal "must have" for these initiatives because someone in the village needs the IT technology expertise, or access to an expert, to know what to do and how to do it (Ashmore et al., 2017; Wallace et al., 2015; Halseth et al., 2019). For example, all successful case studies had telecoms engineers, local IT experts, or access to University resources (Ashmore et al., 2017; Wallace et al., 2015). Thus, technical skills are a non-negotiable CSF. Wallace et al. (2015) include the physical network building skills as part of the "technical capital", including the tools, tractors, ability required to dig trenches, and removal of trees for line-of-sight wireless connections. Ashmore et al. (2017; 2015) and Gerli & Whalley (2018) corroborate

these findings and confirm a local digital champion, technical knowledge and social capital contributed to the success of Broadband for the Rural North (B4RN).

Social capital is a critical ingredient, because it is related to bonding capital (e.g. ability of local leaders to engage local networks & resources without cost) and bridging capital (e.g. ability to engage external networks to solicit financial resources or technical support) (Wallace et al. 2015). Gerli & Whalley (2018) confirmed local community involvement emerged as a critical factor (p. 25). Halseth et al. (2019) validate the findings and found creative partnerships (between all stakeholders) can deliver top quality FTTH, but it requires commitment, creativity, perseverance (by local leaders), support and trust (from residents & local businesses) (p. 154).

In sum, the non-financial capital should be valued when engaging with community-led broadband initiatives. Human, identity (sense of place), technology and social capital engagement at the local level are CSFs and therefore must be considered in this thesis.

3.5.1.2.2 Failure factors

In comparison, there are two failed case studies. One is a bottom-up community-led initiative, Broadband for Glencaple and Lowther (B4GAL) in Scotland, and the other is a top-down public-private partnership (PPP) initiative between a local authority and BT, called Connecting Cumbria (Ashmore et al., 2017; Gerli & Whalley, 2018).

B4GAL failed because of the lack of human capital and technical expertise required to understand the complexities and necessary know-how to negotiate the various stages (see eight-stage model, Table 3.9). The lack of technical expertise thwarted the community on several levels: delays in the project, lack of knowledge on how to negotiate with suppliers, volunteer dropout and waning enthusiasm (Ashmore et al., 2017; Salemink & Strijker, 2018). All these factors caused the B4GAL initiative to stagnate (Ashmore, 2015; Ashmore et al., 2017).

In contrast, Broadband for the Rural North (B4RN) in Lancashire, a bottom-up demand-driven approach, succeeded because it had a strong local digital champion (LDC) with all the leadership and technical skills described above. In the Connecting Cumbria initiative (Gerli & Whalley, 2018) one interviewer stated that the commercial supplier attended the local meetings and used that information against them in

negotiations (p. 419). This created distrust between the local community and the exogenous stakeholders, which reinforced the scepticism communities have when dealing with large commercial suppliers.

The top-down, delivery-driven approach, Connecting Cumbria, failed because of the lack of skills (e.g. human capital) to negotiate with the commercial supplier (Gerli & Whalley, 2018). This initiative was a PPP between the local council and BT. The plan was to reach every property, starting with the "hard to reach" first, but BT's business model focuses on the profitable areas first and then moves out to other areas. BT openly stated the costs required to connect the "hard to reach" are not commercially viable, hence the tension (p. 14). Nevertheless, B4RN's demand-driven bottom-up approach was able to achieve what the local authority and commercial supplier could not, namely FTTH for all premises at a reasonable cost. For example, the original FTTH quotes were £10,000 per premise, but B4RN, through community and volunteer support, was able to reduce the cost to £700 per premise (p. 17).

More specifically, Gerli & Whalley (2018) argue Connecting Cumbria failed because the local government was ill equipped to allocate the funds to the "hard to reach" first, and that BT did not change its business model to accommodate the local resident's needs, naming it an "unequal partnership" (p. 14). These competing ideals and potential power plays are identified in the eight-stage model (Section 3.5.1.1, Table 3.9) to analyse the endogenous and exogenous interplay (Salemink & Strijker, 2016).

The limitations of community-led initiatives are that they are not universally replicable, because not every community has the prerequisite financial, human or social capital abilities to negotiate the various stages for completion. Communities with low financial, human or social capital skills will struggle if they are located outside the current FTTH deployment areas (Salemink et al., 2017b). The reliance on certain actors makes the initiatives vulnerable (Ashmore et al., 2017; Salemink & Strijker, 2018; Wallace et al., 2015).

People move, volunteer's burnout, and hence, robust ongoing business models are required to accommodate for these contingencies or sell the network to commercial suppliers which may or may not be in the best interest of the community (Salemink &

Strijker, 2018; Wallace et al., 2015). Without sustainable business models (e.g. cooperatives who can manage without key stakeholders), the initiatives are vulnerable to people leaving or if funding stops (DCMS, 2016a; Halseth et al., 2019; Wallace et al., 2015).

More specifically, all the case studies were a reasonable distance to a backhaul, telephone exchange or University which made the build possible (Halseth et al., 2019; Wallace et al., 2015). Remote rural communities, that lack these resources or geography to the backhaul, must rely on more expensive or less reliable technologies such as satellite, or wireless access (Williams et al., 2016).

3.5.1.2.3 New opportunities – Altnets – local community engagement

Despite these limitations, new opportunities are developing for the "hard to reach" rural areas. Altnets, explained in (Section 1.4), are new market players wanting to collaborate with local communities to resolve the digital divide. The Altnets are relying on strategic partnerships and innovative business models (Gerli et al., 2017; INCA, 2012). New and creative endogenous and exogenous networks are forming. Hence, the next decade will be of interest in solving the rural quality digital divide.

Furthermore, new technologies, such as TV white space, are being successfully trialled in Wales by alternative networks (Broadway Partners, n.d). TV white space is a new technology rolled-out by Microsoft to utilise the old television analogue connections that have been freed up when communications went digital (Taylor, 2018). TV white space trials have been held in Wales (at 30Mbps), but they are working on developing UFBB.

In summary, alternative networks and technologies, alongside creative partnerships and collaboration with local communities, could help bridge the gap in providing NGA services to the final 95k. Future research gaps include local development approaches are best served as a joined-up approach, with participation on multiple levels, and more multi-method studies are required (Ashmore et al., 2017). Viability of different infrastructure models, the scalability of models and the availability of skills is another identified gap (Gerli & Whalley, 2018).

More consultation and research with local communities is required to uncover the unique qualifications and capitals embedded in remote rural communities (Halseth et

al., 2019). Halseth et al. (2019) argue the minimum requirements to replicate community-led initiatives are necessary and must *"include government financial assistance and training supports, as well as local leadership and stakeholder collaboration"* (p. 119). These are the research gaps this thesis seeks to explore. However, the following section identifies how others have approached local community engagement.

3.5.1.3 Community engagement to develop digital strategies

Four studies are included in this section which reviews the various literature on how local communities are approached to develop digital strategies. Due to the different approaches, in advanced western countries, several definitions and models will be introduced to understand the various lenses scholars have used to study this area. This section combines various concepts previously addressed under community-led broadband studies by investigating endogenous strategies (Erdiaw-Kwasie & Alam, 2016), mixed endogenous and exogenous strategies (Gallardo, 2018; Hosseini, Frank, Fridgen, & Heger, 2018).

Core concepts in this section are related to "cultural contexts", "local contexts", and "innovative ecosystems". In Australia, Erdiaw-Kwasie & Alam (2016) context is how remote rural communities relate to mining companies. It is not necessarily about rural broadband supply and demand per se, but it is about trialling approaches for digital development in rural communities by filling the local cultural context gap.

3.5.1.3.1 Rural partnerships & smart towns - Definitions

In Australia, Erdiaw-Kwasie & Alam (2016), cite Furmankiewicz's 2014 definition of a rural partnership for endogenous development as *"the act of bringing diverse public and private resources together into innovative collaborations to strengthen communities and improve life in rural settings*" (p. 214). The authors relate rural partnerships as endogenous development and draw from the EU LEADER program's critical success factors (CSFs) to engage grass root partnerships: the competence and commitment of partnership staff, the successful mobilisation of local knowledge, needs and resources, and decision-making at the local level (p. 216).

In the EU, Hosseini et al. (2018) adaptation of an open innovation framework to develop "smart towns", as juxtaposed to "smart cities". The authors define smart towns

as *"a town or rural area that is intermediate or thinly populated, but nonetheless provides appropriate and future-oriented ICT solutions to improve various domains regarding economy, people, governance, mobility, environment, or living*" (p. 245). To develop solutions for smart towns, some differentiation to smart cities is required. The authors introduce three problem-adjusting factors (p. 249).

1. Considering local context factors.
2. Ensuring local stakeholder involvement as well as gathering information.
3. Identifying smart solutions.

3.5.1.3.2 Models for local community digital engagement

The literature reveals various models for rural and local community development in the digital age. For example, in the USA, Gallardo (2018) explains the Intelligent Community Outreach Programme (ICOP) as a longitudinal process of increasing awareness by engaging with the community, mapping assets after community buy-in, implement and document the actionable goals and assign responsible parties, and recognition through the Intelligent Community Forum (ICF) awards programme (ICF, n.d-b). The Mississippi State University Extension Programme (MSU), and its Intelligent Community Institute, are associated with the Intelligent Community Forum (ICF) think tank and global network (MSU, n.d). The ICF is now promoting the *"new connected countryside"* initiative to bring rural communities into the 21st century (ICF, n.d-a).

In the EU, Hosseini et al. (2018) introduce the first, to their knowledge, "Open Innovation Framework" to engage an "inside-out, outside-in, and coupled OI approach". These terminologies and concepts are derived from Chesbrough and numerous other innovation management scholars and will be discussed further in (Section 3.7). Hosseini et al. (2018), cite Barca et al. 2012's work, to highlight the importance of more place-based approaches to regional development (e.g. local milieu model) stating that context matters regarding the cultural, institutional and social influences (p. 247). This finding is supported by Diaz Andrade & Urquhart (2009) research in Peru highlighting the importance these factors play in the success of rural community ICT engagement. It is similarly reflected in Putnam's work on social capital, which identifies cultural and institutional influences as critical success, or failure factors, in Italian municipalities (discussed further in Section 3.6.6). Hosseini

et al. (2018) draw from the innovation management (IM) literature, using the terminology of "integrated approaches" and "innovative ecosystems" to develop their methodology to discover how to cultivate smart towns (see Section 3.7.1). The authors define the coupled process as comprising stakeholder collaboration and co-creation to develop innovation opportunities (p. 247). This is a relevant concept for this thesis. The bringing together of endogenous and exogenous collaborative networks for innovation development.

In Australia, Erdiaw-Kwasie & Alam (2016) develop the "Divide-Partnership-Development Framework" aiming to bridge the digital divide through partnership. There are three stages one leading to and influencing the next: digital divide challenges (e.g. access, content & skills); rural partnership challenges (e.g. mismatches in interests, widens power inequalities, exclusion), and rural development (e.g. lop-sided, non-participatory & unsustainable) (p. 222). Salemink et al. (2017) have already addressed many of these concepts, but it is worth noting how other scholars have empirically investigated the problem.

Additionally, in Australia, Alam, Erdiaw-Kwasie, Shahiduzzaman & Ryan (2018) collect data from the social cognitive and the Unified Theory of Acceptance and Use of Technology theory (UTAUT) to inform a SWOT analysis to assess regional digital competence. The authors use a SWOT analysis *"to explore the experiences of people with digital initiatives; the challenges they face in accessing digital resources and the opportunities to realise their personal and collective goals"* (p. 64). The results indicate that digital orientation, adoption and usage are critical (p. 65).

Limitations to these studies are indicative of rural communities regarding economies of scale and generalizability of results (Hosseini et al., 2018). Future research gaps are the requirement for more responsive and localised approaches (Erdiaw-Kwasie & Alam, 2016; Gallardo, 2018; Jackson & Gordon, 2011). The following section will summarise the primary concepts identified in the community-led broadband literature.

3.5.1.4 Summary of community-led broadband

Neo-endogenous local actors, assets, networks, resources, the value of human capital, social capital and trust are required (Bosworth & Salemink, 2014, June; Salemink & Strijker, 2016; Salemink et al., 2017a). The cooperative interplay and mutual learning between neo-endogenous actors are a key for successful rural broadband initiatives.

Community-led broadband critical success factors (CSFs) are confirmed throughout the extant literature (Section 3.5). Local digital champions (LDCs) who possess the knowledge (e.g. human capital), networks and trust to engage the community (e.g. social capital) are successful (Ashmore et al., 2017; Wallace et al., 2015). LDCs created a demand-aggregated model that utilises the rural vouchers to provide the financial capital, coupled with local volunteers to deliver the service to the whole community (Gerli & Whalley, 2018; Halseth et al., 2019). Thus, the local community component is a CSF (Ashmore et al., 2017; Gerli & Whalley, 2018; Salemink et al., 2017a).

The most successful UK rural FTTH projects are B4RN and its sister initiative, MyFi, in Michaelston yr Fedw in Wales (B4RN, 2011; Jackson, 2019, May 21; MyFi, 2018). Moreover, these two projects are united because the brother-in-law of the successful B4RN initiative inspired his brother-in law in Wales to create MyFi. This is another example of a “non-financial” value-add of local human capital, plus the value of bridging and bonding social capital networks in knowledge flow to provide innovative solutions.

Failure factors included lack of skills (e.g. human capital), volunteer burnout and waning enthusiasm from project delays (Ashmore et al., 2017; Salemink & Strijker, 2018). Vulnerabilities include over reliance on leading actors, and the need for sustainable business models. Criticisms of community-led initiatives include putting too much pressure on communities to negotiate or who do not have the prerequisite human capital to succeed (Bosworth & Salemink, 2014, June; Salemink & Strijker, 2018). Battles over competing ideals between local authorities and commercial suppliers overriding community intentions, and the potential misallocation of funds, can cause distrust and failure of projects (Ashmore et al., 2017; Gerli & Whalley, 2018).

Opportunities include the development of innovative business models, strategic partnerships and new technologies (Gerli et al., 2017; Taylor, 2018). The eight-stage model (Section 3.5.1.1, Table 3.9) can be used to identify symbiotic relationships between the endogenous and exogenous actors, and discover the unique capitals embedded in remote rural communities (Halseth et al., 2019). Core concepts identified in the literature include developing innovative ecosystems, exogenous and endogenous local actors, human capital (e.g. local entrepreneurial leadership, IT knowledge and skills), place-based (e.g. local milieu), social capital (e.g. the value of networks and trust), and stakeholder co-creation and collaboration (Díaz Andrade & Urquhart, 2009; Hosseini et al., 2018; Leong et al., 2016).

The gaps in the literature call for more community engagement at the local level to include all stakeholders and ensure the critical failure and success factors have been considered (Erdiaw-Kwasie & Alam, 2016; Gallardo, 2018; Wallace et al., 2015). The complexities of multi-faceted rural community ecosystems call for multi-stakeholders to work together. The following section will review how supply and demand challenges for reaching the final few have been addressed.

3.5.2 Rural broadband - Supply & demand studies (OBJ1B & 1C)

The challenge for rural broadband can be described as a "chicken & egg" scenario because without reliable supply the demand cannot materialise and vice versa. If there is no reliable demand, then the supply cannot emerge. Henceforth, rural broadband supply and demand studies are often interlinked. The following section will provide a synopsis of RCUK-funded supply and demand summary papers (Section 3.5.2.1) and then divide out the supply studies (Section 3.5.2.2), demand studies (Section 3.5.2.3), in-between supply and demand (Section 3.5.3) and more recent FTTH, NGA, UFBB studies (3.5.4).

3.5.2.1 Supply & demand – Summary papers (OBJ1B & 1C)

There are three RCUK-funded summary papers recently published (2015 & 2017). In order not to duplicate work, and to focus on post-2013 research, the summarised outcomes are presented as a starting point for this section.

A 2015 collaboration study between the University of Aberdeen (RCUK Digital Economy Research) and the Oxford Internet Institute (OxIS) sought to provide

empirical evidence and show the effects that slower broadband speed has on rural Internet use and the services it provides (Philip et al., 2015b). Deep rural was defined in (Section 2.2.2). The report surveys urban, shallow rural and deep rural areas, and provides statistically significant results, including *"deep rural dwellers are significantly less likely to be – and to be able to be – Next Generation Users"* (p. 50). Next Generation Users (NGU) are defined as someone who accesses the Internet from multiple locations and devices (e.g. e-reader, tablet, or owns three or more computers), and who use at least two of the four applications: browsing the Internet, finding directions, using email or updating a social networking site (p. 19). The report found a demographic and population reversal, whereby young adults moved out of rural areas while middle class affluent retirees with disposable income and high levels of education were returning, and Internet use among older users has increased in the last decade (p. 16). This is a significant finding since population age is a factor in deep rural areas regarding demand, use and adoption.

Overall, the analysis provides empirical evidence that infrastructure capability (e.g. both access and speed) influences what users can do online (e.g. first-generation basic-use versus next generation data-heavy use) (p.43). Data heavy use is explained as listening to music, watching films, movies or video download (p. 37). The analysis also confirms that there is a verified digital divide between urban and deep rural access and use. Summaries of the statistically significant findings for deep rural areas are presented in the following Table (3.10).

Table 3.10 Summary of significant deep rural Internet survey results (Philip et al., 2015b, p. 31 and 43)

Aspects of Internet Use – Deep rural results	***Internet Use and Broadband and 3G and 4G speeds***
Non-use is most common in deep rural areas.	SFBB was not available to any of deep rural respondents (survey taken in 2013).
Deep rural Internet users are most likely to be upper middle or middle socio-economic groups than those in other areas.	Broadband speeds exceeding the required to use BBC iPlayer (3.5 Mbps) were common in urban areas.
Use of Internet-enabled features on mobile phones (e.g. email, browsing) is lowest in deep rural.	Low broadband speeds do not appear to prevent next generation use of Internet - but user experience will be influenced by available ICT infrastructure.
Deep rural are less likely to use Internet for entertainment (e.g. streaming films).	Internet users living in unit postcodes with SFBB were more likely to use "data heavy" activities than those without SFBB.
Deep rural least likely to use multiple locations or "on the go" due to poor connection availability.	Social networking was least likely in unit postcode areas with lowest broadband speeds – under 3.5 Mbps – deep rural.
Home working is most pronounced in deep rural.	Social networking most common where SFBB available.
	38% of deep rural Internet users stated their connection was "too slow" – under 3.5 Mbps.

In 2015 another RCUK-funded summary paper was published to showcase the £138m research investment into the rural digital economy (Philip et al., 2015c). The review summarises the topics and how rural areas were affected by new technologies and geographies. Research studies on infrastructure, and the uneven distribution and effects on rural SMEs (reviewed below in 2017 summary). Other research included communications and social interactions, e-health, natural resource management, rural enterprise (e.g. supply chains) and resilience (partially reviewed in community-led Section 3.5.1). The empirical evidence confirms the complexity and diversity of rural areas in the UK (e.g. supply, demand & use), and how access either supports or hinders its progress (Philip et al., 2015a; Townsend et al., 2013; Townsend, Wallace, & Fairhurst, 2015). One notable insight the authors found was the projects were "deeply interdisciplinary" and how University collaborations with non-academic institutions bore fruitful results despite the *"deep epistemological disciplinary differences"* (p. 146). This evidence supports a multi-player collaborative approach to be discussed in (Section 3.7.3).

A 2017 RCUK-funded review article covers supply studies at national policy level, community led initiatives, and shows how the debate has moved on. The review reveals how communities' harness digital technology and are not a homogenous group of users (Roberts et al., 2017b). The community-led initiatives have been discussed in (Section 3.5.1). Other supply-side studies include using a community resilience framework and the challenges of implementing localism (Roberts et al., 2017a), the lived experiences of uneven supply (Philip et al., 2017), and how socio demographic considerations such as education and employment status play a significant role (Park, 2017). The demand case studies address social cohesion on and offline at the community level (Wallace et al., 2017). Benefits to rural MB in the creative sector, and the barriers to business sustainability resulting in out-migration if access is denied or unreliable (Townsend, Wallace, Fairhurst, & Anderson, 2017). The summary findings (Roberts et al., 2017b) include future research to consider *"the development of appropriate technologies and policies and the most effective routes to implementation – whether these be through bottom-up community led initiatives, through Government-led investments and schemes or through partnership which encompasses multiple approaches"* (p. 358).

In summary, in order not to duplicate work, studies considered supplementary to the work already provided by RCUK-funded research will be reviewed in relevance to the research objectives. Nevertheless, more detailed findings of the RCUK research are reviewed in the "in-between supply and demand" studies below (Section 3.5.3).

3.5.2.2 Supply studies – Hard to reach rural areas (OBJ1B)

Thirteen studies were reviewed for this section. However, due to the recent UK Government changes to FTTH and 5G, and the Rural Gigabit Connectivity (RGC) programme from July 2019, this section is in a state of flux. Currently, the Wales Rural Broadband Taskforce are meeting from September 2019 onward to develop plans to roll out the new initiatives. Hence, this section is subject to change. Previous research on achieving universal service (Boik, 2017), and the negative impact on rural communities due to lack of adequate access above 2 Mbps (Townsend et al., 2017) are being targeted by the market change. More specifically, as of October 2019, the market is under-going further changes, including another name change to "gigabit-capable" technologies and may re-visit the "outside in" rural gigabit connectivity approach

(DCMS, 2019a). This section therefore will be a short summary as these developments unfold.

Nevertheless, recent supply side studies included checking rural broadband speeds and the impact of alternative supply models, including community-led initiatives and utility and energy companies (Gerli, Van der Wee, Verbrugge, & Whalley, 2018; Gerli et al., 2017; Philip et al., 2015a; Philip et al., 2017; Riddlesden & Singleton, 2014). Riddleston and Singleton (2014) provided empirical evidence that rural "hamlets – less sparse" areas have slowest speeds, which is corroborated by Philip et al. (2015a) post code analysis. Other studies in the UK and the EU evaluate the investment required to deploy SFBB and 5G technologies if governments are to meet their targets (Feijóo, Ramos, Armuña, Arenal, & Gómez-Barroso, 2018; Oughton & Frias, 2018) and confirm more business cases, business models and investment are required.

Additional findings included barriers for remote rural connectivity is the lack of reliable backhaul (Gerli et al., 2017; Halseth et al., 2019; Townsend et al., 2013). Drivers for alternative solutions, include alternative technologies (e.g. TV whitespace), engaging public utilities for economies of scope, joint ventures and public-private investment models (PPP) (Falch & Henten, 2010; Gerli et al., 2018; Gerli et al., 2017; Taylor, 2018). A noteworthy finding however is that none of the alternative case studies investigated by Gerli et al. (2017) have been profitable and suggests developing unique business models with key partnerships to compensate for the small-scale economies. Innovative business models and creative partnerships were a hallmark of success for the Canadian case study (Halseth et al., 2019). Nandi et al. (2016) confirm, "one size does not fit all", but community-based and self-sustaining business models are required for supply and motivation for adoption.

3.5.2.2.1 Summary of supply studies

In summary, almost all these supply challenges are being addressed in the research context (Section 2.4). For example, the influx of rural gigabit governmental funding, the growing number of alternative suppliers, the barrier busting taskforce, the development of creative business models and strategic partnerships, local authority engagement, the introduction of new technologies (e.g. TV whitespace), the increased political will and so forth. These proactive strategies are changing the rural broadband

supply landscape. Thus, due to the fast-paced current market changes, this section will not be explored further.

3.5.2.3 Demand studies (OBJ1C)

The extant rural broadband literature unanimously agrees digital awareness, skills, and training are critical factors in the adoption and exploitation of broadband services and benefits (Alam et al., 2018; Galloway, 2007; Galloway & Mochrie, 2005; Hallstrom et al., 2017; Jones, Simmons, Packham, Beynon-Davies, & Pickernell, 2014; Phippen & Lacohée, 2016). Overall, 16 demand studies were identified, but a condensed summary is provided. Three were removed because home-based or studies not directly related to rural broadband were considered out of scope (Mason, Carter, & Tagg, 2011; Newbery & Bosworth, 2010; Stocker & Whalley, 2018).

Several demand studies used diffusion theories to understand rural broadband adoption and use. Findings summarised by Salemink et al. (2017b) include the traditional view that remote rural communities are at the end of the diffusion stage (e.g. late adopters & laggards), adoption and use is constrained by supply, and willingness to adopt in business differs within sectors (p, 368). Whitacre (2010) summarises Everett Rogers (1962) *Diffusion of Innovations,* as containing four basic elements: an innovation, communication channels, time and a social system (p.1285). The "adopter categories" are defined as Innovators (e.g. eager to try new ideas. More years of formal education, higher income). Early Adopters (e.g. role models for other members of social system). Early Majority (e.g. interact frequently with peers. Deliberate before adopting new ideas). Late Majority (e.g. respond to pressure from peers. Approach innovation with caution), and Laggards (e.g. resistant to innovation. Suspicious of change. Isolated) (p. 1286). Whitacre (2010) found age, education and income affect rural broadband adoption.

Other predominant diffusion theories and amalgamations included the Bass Diffusion Model, Social Cognitive Theory (SCT), Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT). Dobson, Jackson & Gengatharen (2013) critique the use of TAM for rural broadband adoption as an oversimplification and argue *"it is not solely the ease of use, or perceived usefulness of broadband that drives adoption: the usability, relevance and context of the intended applications also play a significant role"* (p. 971). Peronard &

Just (2011) support this argument and highlight the importance of user motivation within a rural community context encourages usability and relevance for adoption. Nevertheless, LaRose, Gregg, Strover, Staubhaar & Carpenter (2007) in the USA, combine TAM variables with social cognitive variables, and found "expected outcomes" (or relative advantage in TAM terminology) is the most significant predictor of broadband intentions, and "self-efficacy" is a causal link to expected outcomes (p. 368).

Taking a different approach for rural broadband adoption in Australia, Rao Hill, Burgan & Troshani (2011) synthesise Roger's 2003 innovation diffusion model, Venkatesh and Brown's 2011 attitudinal model and Pedersen's 2005 domestication model. The authors found relative advantage (e.g. always on, faster access, faster download), utility outcomes (e.g. attain education materials, perform business or household activities and tasks) and facilitating conditions (e.g. affordability) were the strongest predictors for household adoption (p. 1098). Dobson et al. (2013) cite Horrigan's 2011 study of rural non-adopters in the US, who found no access, cost, lack of skills and perceived lack of relevance as the primary reasons for not having broadband (p. 971).

Overall, the variables and findings reveal similar or consistent barriers to adoption, albeit the "chicken and egg" scenario of no access (e.g. inadequate or unreliable supply), lack of skills and knowledge, and the need for relevance and awareness to promote individual user motivation. LaRose et al. (2007) summarise *"in the end, potential home users must be convinced that broadband will produce positive outcomes in their own lives and develop the self-efficacy they need to be confident they can attain those benefits for themselves"* (p. 371).

In the UK, Townsend et al. (2013) found barriers to adoption include demographic factors (e.g. age, cost, digital literacy, education, lack of interest & income) (p. 584). Alternatively, adoption rates were affected by age, appreciation of potential benefits, income, overall cost of service and previous experience (p. 591). Blank et al. (2018) equally found age and education can hinder take-up in rural areas. In the EU, van Deursen & van Dijk (2015) multifaceted model of motivation found four types of access: motivation (attitudes), material (physical access), skills (development of

content-related skills) and usage (educational or social). The authors found by improving Internet attitudes directly affects access, skills and usage diversity.

Howick & Whalley (2008) investigate drivers of adoption in remote rural Scotland by using the Bass Model of new product diffusion integrated with the System Dynamic Model (p. 1307). The adoption assumption is based on innovators who adopt due to external sources of awareness (e.g. advertising), and imitators who adopt from contact with previous adopters (e.g. word of mouth). The data is older (e.g. analysing dial-up to broadband), but the decision-making criterion for households is cost, frustration with current service, use, skills and security concerns. The drivers for adoption include advertising (e.g. TV), demonstration of broadband benefits and incentive schemes. The authors found both models had shown past policy initiatives had affected adoption (p. 1310).

Insights from a recent Canadian scoping review, beyond infrastructure, on rural broadband adoption and community development analysed the findings in relation to the Flora's Community Capital Framework (CCF) (Hallstrom et al., 2017) identified in (Section 2.2.3). The authors found, for supply studies, substantial emphasis placed on built (or physical) and economic capital to the neglect of cultural, human, natural, political and social capital (p. 25). The demand-side are more balanced, but with a bias towards built (physical infrastructure), economic and social capital (p. 26). The authors aim to mobilise this knowledge into an investment guidebook to raise awareness and engage all stakeholders to find implementation or action plans at the localised level to regional and national-level initiatives (p. 27).

Finally, five studies focused on rural microbusinesses (MBs) and SMEs. Units of analysis included farm diversification strategies and the ICT access and skills required for exploitation (Morris et al., 2017). Lessons learned from SME business support programmes to stimulate demand (Price, Shutt, & Sellick, 2018) found financial support and tailored advice are most effective. A qualitative study of 10 rural SMEs in remote rural Scotland evidenced that without ICT access creative businesses cannot survive, thus enforcing out-migration (Anderson, Wallace, & Townsend, 2016). These findings (e.g. farm diversification strategies, ICT access & skills, tailored SME training advice & government infrastructure investment is required to stop out-migration or prevent rural "brain drain") was confirmed and expanded by Bowen &

Morris (2019). The authors (2019) analysed the impact broadband access has on Welsh agribusinesses. The study surveyed and interviewed farmers (738 respondents & 10 qualitative interviews) and food & drink SMEs (107 respondents of which 64 are rural-based & 9 qualitative interviews). The authors found access to broadband is vital for growth, but technology adoption was an issue for farmers confirming the "chicken & egg" challenges of lack of access (supply) can hinder motivation and use (demand). The difference between the food & drink SME entrepreneurial activities and opportunities (e.g. social media marketing to expand internationally) versus the farmers was highlighted by the "attitude" towards ICT adoption to grow the business. The authors suggest a more "proactive approach" to digital and entrepreneurial activities is required to improve Welsh agribusiness performance, particularly post-Brexit (e.g. to discover & capitalise on new markets). Lastly, not rural broadband per se, but rural SME ICT adoption is positively affected by the value of business clusters and social capital (Steinfield, LaRose, Chew, & Tong, 2012).

3.5.2.3.1 Summary of demand studies

In summary, drawing on a range of factors to encourage adoption, these include access, attitude, awareness of benefits, cost, need versus perceived lack of need, skills, speed and reliability of service, and the supporting role of family and friends. Digital awareness, skills and training are CSFs for adoption and exploitation for rural residents, MBs and SMEs. Rural adopters need to understand relevance and usability, plus relative advantage, self-efficacy, and utility outcomes. Engagement of local community capital is encouraged. Demand aggregation is a CSF for investment, return on investment and re-investment in the local community through "claw-back" contracts (Section 2.3.1 & 3.5.1.1, Table 3.9). Hence, advanced broadband awareness, training and skills development will be required for the successful implementation of NGA products and services in rural communities.

3.5.3 Rural broadband - In-between supply & demand studies (OBJ1B &1C)

Amongst the literature review, numerous studies were re-allocated as neither supply, nor demand but in-between (e.g. impact & capital studies) and some were deemed not fully relevant or out of scope (e.g. macro-level studies, not specifically rural broadband or data too old). As a result, they were removed from the review. These included (McCoy, Lyons, Morgenroth, Palcic, & Allen, 2018) although based in the UK, the

study is not specific to rural broadband and has limited relevance. In the EU, global policy evaluations as described by (Falch & Henten, 2010) were considered to be out of scope. In the USA, new firm locations (data 1990-2000) (Kim & Orazem, 2017), and speed examination (10 - 25 Mbps) were not related to rural broadband (Ford, 2018) and were left out of the review. In Australia, Park (2017) on social exclusion was reviewed in 2017 RCUK-funded summary paper and so is not duplicated.

3.5.3.1 RCUK local-level analysis – Creative rural MBs and resilience

Thirteen RCUK-funded studies are included in this section and will be summarised by lead author. The relevance of these studies to this thesis is the micro-level local analysis.

Roberts focused on summarising the Digital Economy and Resilience (DEAR) and Satellite Internet Rural Access (SIRA) collaborative projects with the School of Engineering at the University of Aberdeen to reach the final few (Electronics Research Group, 2015). Two studies evaluated the impact of SFBB on community resilience through cultural and digital capital (Roberts, Farrington, & Skerratt, 2015; Roberts & Townsend, 2016). Both case studies are derived from DEAR and SIRA. The projects focused on rural creatives (e.g. artistic, craft-based, new creative & traditional industries). Although creatives may not contribute widely to economic development (Roberts & Townsend, 2016), they contribute significantly to other community "non-financial" capital (e.g. developing cultural capital through art, creating contexts for interactions, inspiring heritage, participation & a "sense of place") (p. 199). Roberts & Townsend (2016) found four themes contributing to community resilience: adaptive capacity, cultural capital, leadership and resourcefulness. Equally, creatives use their agency and self-efficacy (e.g. to fundraise, mobilise, organise & set up networks) and use their skills to improve the area (p. 200).

Roberts et al. (2015) explain how community resilience can be broken down into *community assets* (e.g. cultural, economic, natural & social capital) (p. 252). The authors develop a framework for digital engagement and resilience (DEAR) based on three interacting spheres. 1) Individual resilience (e.g. connectivity leadership, digital skills, health & wellbeing, home & mobile working/studying, level of participation, life events & socio-demographics). 2) Digital engagement (e.g. access, attitudes to technology, online networks, public services, take-up, technology as enabler/barrier &

usability). 3) Community resilience (e.g. social capital, social learning, sense of place, wealth & diversity) (p. 258). Findings from both studies echo the call for more endogenous, local and extra-local community capital engagement. Roberts et al. (2015) future research suggests a need for more *"integrated and embedded"* approach (p.255). Finally, Roberts uses the resilience framework to evaluate UK and EU digital policies (Roberts et al., 2017a) and recommend an integrated rural-digital policy approach to support and empower resilient rural communities to develop the resources to fully exploit ICT.

Ashmore focuses on B4RN (Lancashire) and B4GAL (Scotland) studies to assess SFBB on individual and community resilience (Ashmore et al., 2015). Findings include positive effects on individual resilience with increased use of data heavy applications (e.g. video & Skype connecting globally with family and friends) and the benefits of increased control (e.g. freedom to manage individual finances). However, it is not speed for speed's sake. Speed was directly related to reliability of service.

Wallace focuses on remote villages in Scotland, namely Peninsula Village (bohemian-creatives) and Commuter Village (affluent Aberdeen suburb with oil industry engineers). Wallace et al. (2017) evaluated social cohesion, on and offline, through social integration (e.g. commitment to common good & sense of belonging) and system integration (e.g. business & cultural). Findings confirm ICT plays role in social networking through bonding and bridging social capital, albeit with different outcomes (e.g. Commuter Village is more individualised & used ICT to connect personally whilst Peninsula Village community organisation and websites drew people together).

Townsend focuses on creative MBs and how 12 out of 15 interviewees were in-migrants deciding to move to a rural community providing they had some form of Internet access (Townsend et al., 2017). The use of Skype to stay connected and reduce isolation was evident in the SIRA project (Townsend et al., 2015) and the Cornwall artisan rural creatives study (Townsend & Wallace, 2015). Townsend et al. (2016) investigated rural MBs and social capital (e.g. bonding & bridging networks on and offline and the critical development of trust). Significant findings included the evidence of environmental capital impact with the use of Twitter (e.g. free marketing

& broader reach) which reduced the need for travel and the cost of fuel. Sample sizes for all studies were 15-18 creative MB.

Philip and Williams present results from the Rural Public Access Wi-Fi (PAWS) project in South Shropshire (Williams et al., 2016). This pilot project was a micro-level analysis of free satellite provision to discover usage and unlock barriers to adoption. Findings included four categories of potential users of the service: acceptors, ambivalent, disgruntled and potential payers. Suggestions for different models for suppliers, including pay as you go to encourage adoption. In addition, three PAWS home-based MB (e.g. cattle & sheep farm, seasonal campsite and specialist design & printing business) were studied over two and a half years and the research highlights how vulnerable these businesses are to being left behind in a fast-changing digital economy (Philip & Williams, 2019). Finally, Philip et al. (2017) reveal the implications for digital exclusion through postcode analysis and qualitative case vignettes (e.g. using Ashmore's Lancashire, SIRA Shropshire & Wallace's Scotland MB data to illustrate results). Findings detailed the personal frustrations of user experience with poor connections.

3.5.3.2 In-between supply & demand – Quantitative studies

This section summarises eleven quantitative studies that focus on rural broadband implementation (e.g. state aid) or the impact of implementation (e.g. employment). The data sets used are at the country or county-level. This thesis aims to explore the micro community-level. Hence, a short summary is as follows.

Implementation studies

The USDA pilot and farm bill loans program had an impact in reaching under-served rural areas (Dinterman & Renkow, 2017). Similar findings in the EU with state aid positively affected treated versus untreated municipalities (Briglauer, Dürr, Falck, & Hüschelrath, Article in press). However, a natural experiment in the USA analysed federal grant schemes for supply and found the greatest gains were when federal infrastructure grants were coupled with state-funded demand education campaigns (LaRose, Strover, Gregg, & Straubhaar, 2011).

Impact studies

The following studies focus on variables such as age, education, employment and income and whether state aid has had an impact or not. Findings include education and income affect diffusion and adoption in rural areas for residential, the creative class and non-farm entrepreneurs (Conley & Whitacre, 2016; Whitacre, Strover, & Gallardo, 2015; Whitacre, 2010) and broadband impacts local growth through employment (Kolko, 2012). Schleife (2010) found individual characteristics (e.g. age, education & income) and network effects (e.g. strong users motivating non-users) aid adoption in rural areas. Prieger (2013) study on rural mobile broadband found improved gross domestic product (GDP) through indirect channels of attracting investment from outside the area, improving local human capital through improved civic engagement, education, health care and increasing firm productivity and efficiency (p. 499). A significant insight from this study (2013) is two-fifths of rural residents are interested in working from home and are open to telework opportunities, and three-fourths of outsourcing businesses are interested in returning some of those outsourced positions to rural communities if rural employees can fill those roles (p. 497).

Overall, the quantitative studies provide evidence that broadband has a positive impact on rural communities, although more demand-side policies to support adoption are suggested (Boik, 2017; LaRose et al., 2011; Whitacre, Gallardo, & Strover, 2014; Whitacre et al., 2015). The core finding for this thesis is that future research requires more micro-level and small geography analysis to truly understand grant impacts (Dinterman & Renkow, 2017; LaRose et al., 2011; Manlove & Whitacre, 2019; Whitacre et al., 2015). Additional FTTH quantitative studies are summarised below (Section 3.5.4).

3.5.3.3 Summary of in-between supply and demand

In summary, the in-between studies reveal the need and use of SFBB in rural communities has individual, business and community resilience impacts. Evidence of environmental capital and non-financial value-add through creative MBs are required to develop rural capital assets (e.g. cultural, economic, natural & social capital). Speed is considered reliability of service versus speed for speed's sake. Positive econometric

assessments have been found, but more research is required at the micro-level and policies to support adoption.

3.5.4 FTTH, NGA & UFBB - Combined studies (OBJ1B & 1C)

Eight studies were identified in this section from countries outside the UK. Although not all the studies are related specifically to rural, the arguments about FTTH and UFBB are worth noting. Quantitative studies are predominant in this section and the debate over whether or not full fibre is worth government subsidies and who is best placed to deliver it - the market or the government?

In the USA, Kenny & Kenny (2011) critically analyse the government rationale to subsidise FTTH super-fast broadband (50 Mbps & above). The authors dissect each socio-economic assertion (e.g. fibre benefits education, electricity, healthcare, transport, TV & future proofs the system), but find the evidence provided for the argument is based on basic and not FTTH technologies. The authors argue that although the technology is available and superior, the lack of demand cannot justify the cost, and provides examples of super-fast air, sea and train travel for comparison (e.g. Concorde, Hovercraft or Maglev trains). The authors provide a helpful summary of cost-benefit analysis of early broadband (e.g. DSL upgrade costs were $150 for swapping out equipment) compared to the investment of deploying a new full-fibre network (e.g. estimated costs $2750 per home passed) or 18 times higher than DSL. The authors argue there is not sufficient evidence to show the subsidies for FTTH are justified. The authors argue that 90% of US residents live within five miles of the national highway system. Installing fibre during road construction is approximately one percent of total construction costs. Approximately, 15 % of the road network is constructed, rehabilitated or upgraded every year. Henceforth, the authors argue why the rush? The evidence is not there to justify massive subsidies. This study is now a decade old, but the argument is validated in the following studies.

In the EU, Briglauer & Gugler (2019) provide the first evidence of gigabit/UFBB through a cost-benefit analysis of EU27 member states from 2003-2015. The authors found that at 50% FTTH will have a benefit, but at 100% it will have a negative cost impact. This assertion is based on the low take-up rate in EU. Hence, the authors suggest maintaining basic, FTTC and FTTH technologies until the take-up rate and demand for gigabit technologies can be justified. In addition, previous work by Rendon

Schneir & Xiong (2016) demonstrated the cost of deploying a network in a rural area is 80% higher than in the village due to distance from the central office, length of distribution, feeders, drop and in-building segments (p.763). The authors make similar recommendations that a mix of copper, FTTC and FTTH network architectures (apart from wireless & satellite) is required if the goal is 30-100 Mbps. In addition, these quantitative studies suggest more rural demand studies are required to support the full fibre supply studies (Briglauer & Gugler, 2019; Rendon Schneir & Xiong, 2016).

In the USA, taking a different approach, Chakraborty et al. (2018) create a predictive model to measure the impact of full-fibre speeds on local towns and communities. The authors create an index measuring speeds from 25 Mbps, 50 Mbps and 100 Mbps and the economic benefits on household income, annual housing permits, wage, employment and tax revenue. The quantitative study is not focused on rural communities. The unit of analysis are big, medium and small towns (e.g. 12,000 residents). However, the findings are notable, especially for town planners who want to assess if bandwidth expansion will have the desired economic benefits or not. Overall, the authors found bandwidth expansion has differing impacts on towns and local communities indicating the necessity to calculate the economic benefits before deciding on costly long-term investments (p. 1419).

More significantly, Chakraborty et al. (2018) found that a few small towns were *"surprisingly hurt from introducing increased broadband speeds"* (p. 1415). Small towns with less broadband providers, higher median age and are situated further from big cities do not benefit compared to those communities who are located geographically closer to big city connectivity and whose younger demographics take advantage of increased broadband speeds. Thus, validating the requirement of public infrastructure investment analysis prior to assuming full-fibre will have the desired economic and cost-benefit effects.

In the EU, Abrardi & Cambini (2019) provide a useful quantitative literature review of more recent UFBB investment and adoption studies (n= 30 plus). The authors specifically analyse the quantitative methodologies used to analyse economic growth, firm productivity, local development and the interplay with regulation and competition (p. 196). The authors summarise the review into four areas: macro and micro-economic impact, house-hold adoption and review of regulation and competition studies. The

various studies include analysis of basic, DSL and FTTH technologies at national, regional, local and firm levels.

The authors (2019) found macro-economic effects for FTTH has small but significant effect on GDP. Unemployment and labour markets studies found productivity boosts, but no significant effect on employment per se. Micro-economic studies found local employment, does not affect firm's productivity or growth, but has impact on new business creation provided human capital is available. Household determinants for adoption include education, income and quality of content at early adopter stage and price at laggard stage. Tariff diversity, local loop unbundling (LLU) and switching costs from DSL to FTTH need to be reasonable. LLU allows alternative providers to use the existing network assets to provide services. Regulation and competition interplay bounces between DSL (or copper technologies), cable and FTTH. The studies found competitive pressure from cable and mobile affects NGA. LLU lead to faster diffusion in early years, but not as the market matured. The positioning of VDSL slows down fibre deployment because it is less expensive. Operator incentives to invest in fibre are more sensitive to changes in DSL competition if there is extensive LLU. Finally, the authors review some of the studies found above in this literature review (Briglauer et al., Article in press; Ford, 2018; McCoy et al., 2018). In sum, the authors conclude that there is still scant literature that address the impact of fibre investment on economic growth and the assessment on speed differentials, if any, on national or local growth (p. 196). UFBB take-up rates in EU remain low, hence more research on evaluating the network effects is required for sound policy recommendations.

In Australia and New Zealand, UFBB/FTTH studies review and analyse the respective governments national full-fibre deployment strategies. Beltran (2014) summarises and compares the Australian's government-owned versus New Zealand's public-private partnership (PPP) initiative. Howell & Sadowski (2018) critically analyse the anatomy of New Zealand's PPP and the shocking results of when government regulations penalised one of the primary private partners (post-contract completion) resulting in protracted delays and costs to taxpayers. Mirza & Beltran (2014) analyse the adoption of the New Zealand UFBB initiative and found similar results to previous demand adoption studies (Section 3.5.2.3). The multi-method study

of 15 semi-structured interviews and comparison to industry surveys are urban and not rural studies. However, the UFBB adoption determinants mirrored previous studies such as cost, late adopters (e.g. preferring to wait until market matures), and the predominant influence of family and friends for word-of-mouth advertising (e.g. Snap survey revealed Facebook 1% versus family & friends 49% for UFBB awareness).

In Canada, the Eastern Ontario Regional Network (EORN) is an informative case study on how a regional Caucus board, secured federal, provincial and private investment of $180 million (CDN) to build a full fibre network in a predominantly rural area. The area included six First Nations and was able to provide 10 Gigabit Ethernet network to 160 villages, towns and cities covering approximately 50,000 km and almost one million people (Bradley, 2015). Moreover, a qualitative reflexive learning and governance case study analysis of the impact of EORN on rural communities confirmed the four-fold human, social, environmental and financial capital impact on eco-innovative rural farms, SME's and community organisations (Pant & Odame, 2017).

Public-private partnerships (PPP) and government regulation is not the primary focus of this thesis, and numerous debates exist across national, regional and local allocation of funds. There is a lot of criticism of "market failure" hence the need for government intervention, but there are several studies that challenge these assertions. Briglauer & Gugler (2019) argue that the market is better placed to evaluate investment decisions and the above studies maintain that there is not sufficient evidence to justify full-fibre government intervention subsidies. In Spain, the previous government owned monopolies stunted the telecommunications market (García Paramio et al., 2018). The creation of a telecommunication regulator and by breaking up the whole-sale monopoly (e.g. LLU) has helped Spain, and other EU nations, move forward with its NGA network provision in remote rural areas (Abrardi & Cambini, 2019).

3.5.4.1 Summary of FTTH, NGA, UFBB studies

In summary, there is still much debate surrounding the validity of subsidising full fibre networks, although governments are forging ahead regardless of the calls for more evidence to justify the expenditure. If governments enter into PPPs, then it is recommended to consider Howell & Sadowski (2018) analysis of the potential pitfalls in contract negotiations to protect all parties (e.g. taxpayer, government & private

companies). Governments have requested breaking up monopoly telecommunication providers to separate wholesale from retail branches (e.g. BT & Openreach), but the authors recommend ensuring governments do the same by not acting as both investor and regulator. Ideally, more studies to verify the cost-benefit analysis of 100% full fibre coverage and the options to finance these ambitions are noteworthy.

3.6 Rural broadband – Drivers, opportunities, barriers & CSFs (OBJ2)

This section analyses the drivers, opportunities, barriers and critical success factors (CSFs) identified in the literature. Drivers and opportunities are identified in relation to Industry 4.0 and NGA (Section 3.6.1). The supply and demand drivers and opportunities are indicative of the "chicken & egg" scenario and are therefore interwoven in (Section 3.6.2). In addition, barriers to supply and demand are interlinked, but will aim to discuss separately through international, national, regional, community and individual levels (Section 3.6.3). CSFs are required for implementation and take-up in the final few and hard to reach rural areas (Section 3.6.4). Human & social capital are identified across all domains as primary CSFs which provide the theoretical underpinning of this research (Sections 3.6.5 & 3.6.6). A summary of rural ICT definitions for capital terminology is presented in (Section 3.6.7).

3.6.1 Drivers & opportunities - Industry 4.0 and NGA (OBJ2A)

To accelerate internet access and adoption, the WEF (The Boston Consulting Group, 2016) highlight numerous *national benefits* and opportunities with connectivity, including GDP growth, job creation, the future of the Internet of Things (e.g. potential to solve traffic & water hygiene problems), SME revenue growth and quality of life (e.g. agriculture, basic financial services & education). These benefits and opportunities can be viewed as drivers for NGA implementation and take-up. However, there is a negative side which requires risk management to mitigate against cyber security attacks, privacy, trust and so forth (p. 8).

Rural community drivers and opportunities include removing geographic limitations on communication, enabling and supporting economic transactions, and innovation opportunities (e.g. agricultural applications like RFID tags for livestock &

online auctions or farm diversification into tourism) (Halseth et al., 2019; Morris et al., 2017).

In the USA, Gallardo, Whitacre & Grant (2018) literature review on broadband impacts, summarises the current state of play driving NGA and the opportunities therein. The authors separate the literature into various topics, namely economic development (e.g. local economy, entrepreneurship, housing prices, crowdfunding & peer-to-peer lending) although not specifically rural they are areas of research. *Rural studies* are summarised by attraction of new firms, economic growth, higher household incomes, and small business growth. Migration and civic engagement (e.g. less connected are missing improved civic engagement not being on social media). Education (e.g. massive online courses (MOOCs) and teleworking (e.g. gig economy & reducing transmissions). *Industry 4.0 initiatives*, such as artificial intelligence (AI), agriculture (e.g. GPS, precision farming & unmanned vehicles, but lack the capacity to upload large datasets), big data, smart cities and tele-health (Gallardo et al., 2018). This literature review is a recent analysis relating to NGA services, but other supply and demand drivers and opportunities are identified in the following sections.

In summary, the benefits and opportunities driving implementation and take-up of NGA and Industry 4.0 initiatives relate to economic stimulation, growth and various innovation opportunities for human (e.g. education), social (e.g. migration), environmental (e.g. teleworking) and financial capital development (e.g. innovative business opportunities).

3.6.2 Drivers & opportunities – Supply and demand (OBJ2B)

As previously discussed, drivers and opportunities for supply and demand are interwoven because of the prevailing argument that you cannot drive NGA demand opportunities without NGA supply. Henceforth, the barriers to NGA supply and demand will be addressed separately but are interlinked because of the "chicken & egg" scenario.

For example, new business models are being promoted by WEF to resolve the digital divide (Section 3.6.2.2). Therefore, this initiative can be viewed as an innovation driver and opportunity to resolve the digital divide, but also as a barrier busting initiative. Similarly, new community funding initiatives are a driver and

opportunity, but studies highlight the barriers to the implementation and success of these initiatives. The following section aims to identify drivers and opportunities for the implementation and take-up of NGA, followed by the prevailing barriers despite the studies being interspersed (Section 3.6.3).

3.6.2.1 Drivers & opportunities – Supply

To resolve the supply challenges the following initiatives have been identified as drivers and opportunities to promote implementation. As explained above, the WEF (The Boston Consulting Group, 2016) states innovation in technology and business models, has *"proven to be a powerful barrier breaker"* (p. 14). Hence, new and innovative collaborative efforts, coupled with advances in technology could bridge the digital divide gap.

In the UK, the "Barrier Busting Taskforce" (DCMS, 2017) is addressing the macro and micro challenges faced by the government, local authorities and communication network providers. In December 2018, the DCMS launched the "Digital Connectivity Portal" as an information platform to improve collaboration between local authorities and market players to connect local areas. The portal provides information on public sector assets, how to navigate access agreements, and issues relating to use of areas such as highways and so forth (DCMS, 2018, December 20). The 5G barrier busting task force includes increasing the length of masts and utilizing public sector assets such as streetlights and improving spectrum access (DCMS, 2018b). As stated, this section is in a state of flux, particularly in light of the rural gigabit connectivity programme and the introduction of competition to the market (DCMS, 2019c; INCA, 2017).

In the USA, Jackson & Gordon (2011) evaluate the barriers and opportunities for community-based organisations (CBOs) when engaging in federal funding for community broadband. The Broadband Technology Opportunities (BTOP) provided community funding for infrastructure, marginalised populations, public computing centres and sustainable adoption (promoting take-up through training & awareness). The Broadband Initiative Programs (BIP) was focused on rural infrastructure development, but no allocation for public computing or sustainable adoption (p. 2). Like the BDUK initiatives, the onus is on the local community to apply for funding (DCMS, 2019b; Openreach, 2019b).

Empirical evidence from 27 grassroots initiatives revealed the complexities communities have when dealing with funding applications. Successful BTOP applications included partnerships with Universities who had histories of working together (e.g. trust), or through social enterprises who had the same familiarity (e.g. human, social & institutional capital). Failure resided in compressed timelines (e.g. six weeks to submit). Bureaucratic and accounting requirements (e.g. expertise required in the complications & data required in grant writing). Scale and mission alignment (e.g. government allocation of large figures for immigration or homeless groups, but not providing smaller grants for smaller communities without that focus), and limits to the programmes (e.g. rural communities had no support for sustainable adoption training which is a major barrier alongside infrastructure access) (p. 4). Similar to the eight-stage model and Cybermoor "Broadband in a Box" (Cybermoor, 2016; Salemink & Strijker, 2016) community initiatives are often "capital intensive", and the right human & social capital expertise needs to be in place for these to be successful. Jackson & Gordon (2011) make several recommendations to improve the fairness of the programme, but one is relevant to this thesis (p. 9).

> *"According to our interviewees, spaces like community centres, churches and training centres might not be traditional anchor institutions, but they are often key throughways for broadband access because they provide sites which members of the community already have local networks and trust invested in these organisations."*

The BDUK rural gigabit connectivity programme (RGC) strategy is providing funding to anchor institutions, namely GP surgeries and schools (DCMS, 2019c). However, communities without these anchor institutions, or who live in distances not readily reached by these institutions will be left out of this funding. Jackson & Gordon (2011) conclude the BTOP and BIP initiatives failed to engage a principal stakeholder, the community-based organisations, whose existing roots, relationships and networks (e.g. social capital) would have helped proliferate the funding to target areas. Recent observations during the Taskforce meeting in September 2019 echoed the need for governments to broaden the anchor institution definition.

3.6.2.1.1 Summary of drivers & opportunities for supply

In summary, drivers and opportunities for supply implementation include the innovation of new business models (e.g. collaborative approach) and barrier busting initiatives at local authority level. Moreover, state aid funding, should include assistance for local communities to access and allocate funding opportunities and the value of social capital to target and disseminate funding. Notably, failure factors to funding included lack of human capital skills (e.g. funding application knowledge), bureaucracy, compressed timelines & lack of community engagement to include adoption stimulation alongside supply initiatives (e.g. chicken & egg together for rural communities).

3.6.2.2 Drivers & opportunities - Demand

To resolve the demand challenges the following initiatives have been identified as drivers and opportunities to promote take-up. To stimulate demand, the UK Government and BT have developed various initiatives, including the Digital Inclusion Programme (run by BT) and Business Support Programmes (Gerli & Whalley, 2018; Price et al., 2018). However, putting the onus on the commercial supplier versus the local authority can be a disincentive. The "claw-back" clause should be an incentive for local authorities to stimulate demand.

Community-led initiatives included B4RN developing an "IT Club" to support the community and many older residents took advantage of the opportunity which is a critical demographic in rural areas (Ashmore et al., 2017; Philip et al., 2015b).

In Wales, one local authority is taking a focused and proactive approach to engage demand aggregation and supply at the same time which will be investigated further in this thesis (Pembrokeshire Council, 2019, August 1).

3.6.2.2.1 Summary of drivers & opportunities for demand

In summary, drivers and opportunities to encourage demand include training initiatives, incentives for local authorities to promote take-up (e.g. value of claw-back clause for re-investment in community) and proactive approach by local authority to combine supply and demand (e.g. chicken & egg) aggregation.

3.6.3 Barriers to rural broadband (OBJ2C)

The World Economic Forum (WEF) (The Boston Consulting Group, 2016) identifies four barriers in providing Internet for all, including (p. 12):

1. *Infrastructure* to increase backhaul and improve regulatory frameworks and tax systems that provides investment incentives.
2. *Affordability* to make connections and hardware more readily available and cost effective.
3. *Lack of skills and awareness* which are considered the greatest barrier.
4. *Digital ecosystems* to produce *local content* which are considered advantageous to promote adoption.

The report focuses on developing nations, but the barriers and interweaving of supply and demand are relevant to this study. More specifically, the report makes suggestions to create an action plan that relates to this thesis. For example, addressing the underlying local environment and barriers, multi-party cooperation and coordination, and draw upon the best practice of collaboration amongst stakeholders (p. 27).

Moreover, these barrier findings are verified through an OECD analysis of 31 countries on bridging the digital divide (OECD, 2018) and throughout the extant rural broadband literature. Thus, barriers to rural supply implementation and demand take-up include the following areas:

1. **Governmental barriers** include cost, geography, return on investment and rolling out the backbone (Blank et al., 2018; Halseth et al., 2019). High prices and lack of competition (Gerli & Whalley, 2018).
2. **Commercial supplier or market barriers** include cost, geography, low population density, investment incentives, return on investment and spectrum access to induce competition (Cadman, 2019; Philip et al., 2017; Wales Rural Observatory, 2009).
3. **Community barriers** include distrust of market players and government failings, and the commitment, finances, leadership, scale, scope, skills, and perseverance to overcome supply barriers (Ashmore et al., 2017; Gerli & Whalley, 2018; Salemink & Strijker, 2016).

4. **Individual barriers** include age, cost, education, motivation, the lack of skills, low awareness and low perceived value of advanced broadband and NGA benefits (Blank et al., 2018; Cardiff University, 2019; Philip et al., 2017; White, 2017).

3.6.3.1 Summary of barriers to rural broadband

In summary, there are multiple barriers to overcome from governmental, supplier, community and individual levels. The barriers can be summarised to relate to financial capital (e.g. costs), human capital (e.g. lack of education, skills & so forth), social capital (e.g. low population density, community leadership) and environmental challenges (e.g. geographical barriers). To overcome these barriers, the WEF recommends focusing on the local area and barriers, and identifying the best practice cooperation, coordination and collaboration amongst multiple stakeholders.

3.6.4 Critical success factors (CSF) (OBJ2D)

The rural broadband literature identified numerous CSFs to be incorporated into this study. Throughout the rural broadband and innovation management literature there are four primary CSFs identified.

Unquestionably, a *local champion* (or product champion in IM literature) is a critical requirement for ICT success (Ashmore et al., 2017; Cybermoor, 2016; Dutton & Peltu, 1996; Ley et al., 2014; MyFi, 2018; Rothwell et al., 1974; Wallace et al., 2015). Local grassroots entrepreneurs and local digital champions (LDCs) are the driving force for the implementation and on-going success of SFBB in rural communities (Ashmore et al., 2017; Leong et al., 2016; Wallace et al., 2017).

The second most critical factor is the need for *technical IT skills* (Wallace et al., 2015). In the study of success and failure of rural broadband initiatives, technical skills were the critical factor in why one initiative failed against the other (Ashmore et al., 2017). The lack of technical skills to understand how the ICT network is mapped and options for implementation is crucial to fundraising and delivery of the project. Other technical skills identified involved digging ditches, line of sight and other equipment skills required for this process (Cybermoor, 2016).

The third CSF is the *value of social capital* that cannot be underestimated. Roche & Jakub (2017) found that a significant breakthrough came through the understanding

of the value of social capital in the success of investment in an area. Social capital binds the community and promotes teamwork often without financial cost (Ley et al., 2014; Townsend et al., 2016; Wallace et al., 2015; West, Salter, Vanhaverbeke, & Chesbrough, 2014).

The fourth CSF, which is tied directly to human & social capital, is *trust*. The value of trust cannot be overestimated. It is the glue that holds the society together and enables individuals to work together to achieve goals (Mayer, Davis, & Schoorman, 1995; Putnam, 1993; Roche & Jakub, 2017; Schultz, 1961; Wallace et al., 2015). Trust is also equated to individual ability or skills required to do the job (Mayer et al., 1995; Osborn, 2014; Schoorman, Mayer, & Davis, 2007). Restoration of trust will be necessary to restore negative ICT brand reputation and governmental support (Gerli & Whalley, 2018).

In summary, the CSFs are core concepts that need to be included in this thesis if the community-led broadband initiatives are to be successful. Absence of the CSFs have been identified as failure. Thus, the aim is to incorporate the empirical evidence to ensure these factors are involved.

3.6.5 Human capital (HC) - CSF

Human capital is a concept used throughout the extant literature and considered a CSF in the successful implementation of community-led engagement on both the supply and demand sides (Ashmore, 2015; Wallace et al., 2015). Digital skills are required to fully exploit the technology (Knight, 2015; Philip et al., 2015b), and regional and tacit local knowledge is required for successful implementation (Halseth et al., 2019; Wallace et al., 2015). The development of human capital is also one of the four-fold benefits of SFBB implementation (Phippen & Lacohée, 2016). This section explains the theoretical constructs underpinning this study.

Human capital theory

The development of human capital as a theory, begins with Theodore Schultz (1961) known as the "father of human capital theory". Schultz popularised the term and won a Nobel Prize for his work in economics in 1979 (Nobel Prize, 1979). Schultz was one of the first to argue that although it is obvious that people have a unique set of skills, talents and useful knowledge to contribute to society and economic production, it was not obvious at the time that these can be considered a form of capital which required investment (Schultz, 1961). The human capital theory (HCT) has had an influential impact on government policy by stating education and training is required for economic growth (Lazear, 2015; Tan, 2014). Other Nobel Laureates have built their careers on studying and developing the rate of return on human capital, including Gary Becker (Nobel Prize, 1992) whom Milton Friedman described as the most important social scientist towards the end of the twentieth century (Lazear, 2015).

Some have criticised HCT by saying that it can debase workers as property or marketable assets which has echoes of slavery (Schultz, 1961; Tan, 2014). The very concept of slavery is abhorrent, and the concept of free people is to be protected. Enslavement is not what Schultz and other theorists in HCT are claiming. Schultz (1961) advocates that when people invest in themselves, it increases the choices available to them and is one way free people can improve their quality of life (p. 2). HCT aims to promote investment in human capital as a positive means for the individual, the economy and society by expenditure in economic development, education, health care and training (Becker, 1994). Schultz and Becker advocate that human capital can be accumulated (e.g. education & training) or squandered (e.g. lack thereof). According to Lazear (2015), more than any other economist, Becker linked education directly to wage enhancement and living standards (p. 83). Friedman, Schultz and Becker were all contemporaries of the University of Chicago and pioneered many of these enduring economic theories (Becker, 1994). Roche & Jakub (2017) are incorporating human capital into their mutual business model but are challenging some of Friedman's "profit-only" assumptions. Their goal is to provide a new paradigm of economic study by showing investment in human, social and environmental capital can bring improved economic returns. Becker (1994) liked to

surmise about new research, it "removes a little bit of the mystery" surrounding the social and economic world in which we live (p. 25).

3.6.5.1 Summary of human capital

In summary, human capital is critical to the economic development of rural communities and the successful implementation of community-led initiatives (Terluin, 2003; Salemink & Strijker, 2016). Notwithstanding the human capital and entrepreneurship required to capitalize on the "creative destruction" being touted by Industry 4.0 opportunities for rural communities (Abrams, 2007; The Boston Consulting Group, 2016).

3.6.6 Social capital (SC) - CSF

Social capital is similarly considered a CSF, and an additional theoretical underpinning, to be explored in this section.

Social capital theory

The "father of social capital" is attributed to James S. Coleman (McElroy, Jorna, & Van Engelen, 2006). Social capital has been studied extensively in the past three decades (Payne, Moore, Griffis, & Autry, 2011). Physical capital can be any form of equipment that aids in productivity (Coleman, 1988, p. S101). Human capital is the unique set of skills, attributes and knowledge of an individual that contributes to productivity (Schultz, 1961). Social capital is the utilization of relationships that bring about productivity, but only if certain variables are in place. For example, trust is critical. Extensive trustworthiness can accomplish much more than groups who lack trust (Coleman, 1988). This variable is confirmed by Putnam's (1993) extensive work on what makes communities prosperous and how trust lubricates social life; societies who rely on reciprocal agreements are more fruitful than distrustful societies (p. 3). Coleman (1988) uses four examples to explain the variants in social capital. The Diamond District in New York (e.g. strength of family & close community relationships). South Korean student radical activists (e.g. power of organised social capital). A mother of six children moving from one city to another for safety (e.g. benefits of social capital). Kahn El Khalili market in Cairo (e.g. interconnected or infused relationships).

An example of the value of business social capital is in the New York diamond district. The diamond sellers' hand over the merchandise to potential buyers, for inspection in their private quarters. This kind of trading is an impossible task without trust because the diamonds could be stolen or replaced with inferior objects. If the trust quotient is high, then business can be conducted without additional hindrance or costs. If the trust quotient is low, then an entirely different approach to business must be implemented that may include hiring outside parties as witnesses for the inspection or some form of insurance and conflict resolution if anything goes awry. The New York Diamond District has a dense population of Jewish traders who live in the same neighbourhoods, attend the same synagogues, inter-marry and have a social structure that Coleman describes as "closed". Trust is often nurtured within closed social groups because close contact and reputational development can be made when everyone knows everyone else, and there is moral accountability. Trust allows the business to flow with less hindrance because this kind of social capital exists. The similar organisation can be said of the Kahn El Khalili market in Cairo where all the traders are interconnected through family relationships, and everyone aids one another in sales and commissions. The relationships become resources that can be used to achieve their interests and establish "credit slips" with one another that can be redeemed at later dates. It is a system of credits and debits. Information flows between the relationships and subsequent networks.

The value of social capital depends on the social organisation and the reciprocity and trust of all the actors (Putnam, p. 3). Trust and proper credit are required. Meaning, if the favour is done for someone, and they disappear or do not reciprocate then the credit system falters, and trust is diminished. Reputational trustworthiness is valuable. Untrustworthy behaviour corrupts the system. The examples Coleman provides are helpful and have both financial and non-financial benefits. Trading diamonds freely and working together in markets reduces costs and increases trading (financial benefits) and moving to an area with higher social capital provides peace of mind for parents raising their children in a city with diminished crime rates (non-financial benefits). In general, social capital can be summarised as the trust, beliefs, norms, rules and networks that constitute the value of relationships for collective action (McElroy et al., 2006). The aim of this section is not to do an exhaustive literature

review on social capital, but to introduce essential authors, concepts and general applications over the past three decades (Payne et al., 2011).

Portes (2014) criticises Coleman's assertions that social capital is only a positive construct. Portes & Landolt (1996) provide examples from other studies that reveal the negative side to social capital. For example, groups can exclude or restrict outsiders. Not being in the right social circles or conforming to the social pressures versus expressing individual thought can be oppressive. The examples Portes & Landolt (1996) use focus on "small town thinking" or "family clans" such as Chinese, Irish or Italian, or criminal gangs such as the mafia or youth gangs. The authors recognise there is considerable social capital in poorer areas but argue these assets do not necessarily raise people out of deprivation (p. 5).

Economists, Roche & Jakub (2017) are introducing new management thinking and practices to engage the "final few" and hard to reach areas. The authors define social capital in a business context as *"the community level (or group) rather than at the individual level and is the second component, along with human capital, of how people can be valued as an asset"* (p. 69). The author's state that just as human capital can have a positive or negative impact on business performance, social capital can also have a positive or negative impact. Similar to financial capital, human & social capital can be accumulated and valued or diminished and squandered. The authors make use of the term *social fertility* in describing communities. Meaning, is the ground fertile to sow business investment and how can companies assess this fertility? Alternatively, if the social fertility is poor how can businesses influence the community to make it more fertile?

This concept is confirmed by Putnam's (1993) Italian experiment on 20 regional government institutions success or failure and confirms the regions with strong social capital are far more successful than regions without social capital. Putnam (1993) reveals how some of the new governments were spectacular failures. These regional governments were characterised as being corrupt, lethargic and inefficient. Others were notably successful, contributing widely to the benefit of the community (e.g. introducing job training centres & innovative day-care) and by managing the public business with community satisfaction and financial success (p. 3).

Nam Lin (2002) contributes to the debate and defines capital as an *"investment of resources with expected returns in the marketplace"* (p. 3). Lin explains the history of capital by comparing classical theory based on Marxist views on capital (e.g. surplus profits made by labour) to neo-classical based on human capital theory. In summary, Marxist views the capitalist elite as subjugating the masses for personal profit and hence the distribution of wealth is unbalanced. Schultz (1965) argues that individuals are not subjugated and are free to develop human capital to provide value to themselves. The battle between socialist (or more equitable distribution of capital) versus capitalism (the freedom of the individual to create) is an enduring debate and connected to cultural bias (refer to Section 3.2.4.2).

Nevertheless, Roche & Jakub (2017) challenge these opposing views by holding multi-national companies (MNC) to account, and introduce a new model into capitalism, called "mutual business" (or the economics of mutuality) that challenges businesses not to focus solely on profit, but to value all forms of capital including environmental, human and social. This new thinking could assuage the increasingly frustrated debates in western media over the abuse of corporate and public funds (e.g. 2008 banking bailout) and concern over climate change. Socialists would appreciate the economic accountability and shared capital distribution from multi-national corporations (MNCs). Environmentalists would appreciate the value and inclusion of their concerns and contributions upfront in the business model. Capitalists and entrepreneurs can continue to create wealth with new opportunities, but with a more accountable, holistic and mindful approach to the communities in which they operate. People will be appreciated and valued, and the human & social capital can be built upon, individually and collectively, for the betterment of all stakeholders.

Notably in a rural community context, Salemink, Strijker & Bosworth (2016) argue classical models overlook two essential factors. They cite earlier work in 2005 by Castells that regions are not closed economies but instead are interconnected, as well as Capello's view in 2011 that growth can occur from innovation, learning, and the development of human & social capital within groups (p. 106). Therefore, the authors draw together the key elements of interconnectedness, innovation, human & social capital in rural communities as drivers of economic growth. As a result, Salemink, Strijker & Bosworth (2017a) argue that a contemporary approach to regional

development, must involve the complexities of rural communities with various stakeholders and network of actors, whereby trust is an asset to reduce costs and facilitate the knowledge economy. The neo-endogenous (NED) approach to rural development aims to develop the human & social capital between the internal and external networks and cite Fukiyama's 1995 definition of social capital as *"an informal norm that promotes cooperation"* (Salemink et al., 2017a, p. 6).

Two decades ago, social capital was dismissed by economists, but today they recognise it as a fundamental key to economic growth (Sciences Po, 2016, June 15). In fact, the OECD has since correlated over 50 country surveys resulting in a 1200 question data bank to measure social capital (OECD, n.d.). Henceforth, social capital is a core measurement for economic and social wellbeing.

3.6.6.1 Organisational trust - Ability

The concept of trust is fundamental to the function of social capital and is a CSF in rural broadband initiatives (Section 3.5.1.2.1). The definition of trust in social capital is often related to reciprocity (e.g. can the lender trust the borrower to return the goods). Reciprocal trust is often on a one-to-one basis and/or conducted within closed or familiar networks. When considering the importance of trust within organisations and unfamiliar networks where relationships are more complex and one-to-many basis, a broader definition was required.

To expand the definition of trust, particularly within organisations and networks, a highly cited and influential study on organisational trust was consulted. In this study on organisational trust (Mayer et al., 1995), the authors cite a famous 1950 Yale study on communication and persuasion or attitude change (Hovland, Janis, & Kelley, 1953). These psychology researchers demonstrate how significant ability is to enabling trust. Meyer et al. make a significant distinction in their conclusion (p.717):

> *"The question, "Do you trust them?" must be qualified: "trust them to do what?" The issue on which you trust them depends not only on the assessment of integrity and benevolence but on the ability to accomplish it".*

More notably, trust within the context of this research is tied to **ability** or how to "get the job done" and reach the final few. Therefore, defining human & social capital, within the context of trust, is defined as the ability to accomplish the goal of getting

NGA (supply) to the final few rural areas (demand). Social capital and reciprocity of trust within the rural community will be measured at the local-level to determine the "social fertility" or trust quotient for investment. However, trust within the supply and demand networks, will focus on the ability to get the NGA (product) to a final few (market).

3.6.6.2 Summary of social capital

In summary, the extant rural broadband literature identified social capital as CSF for the implementation and development of advanced broadband in rural communities (Section 3.5.1). The importance of valuing endogenous local skills and bonds (human & social capital), the necessity of exogenous bridging networks (social capital), and the trust required to unite all stakeholders to "get the job done" and reach the final few are areas to be addressed in this thesis (Moseley & Owen, 2008).

3.6.7 Rural ICT definitions for capital terminology

The rural broadband literature introduced various capital terminologies. Flora (2016) identified seven rural capital assets in (Section 2.3.3). In addition to these rural capital definitions are definitions introduced by rural broadband studies. To simplify, summarise and focus the terminology, the four-fold capital benefits will capture the various definitions in relation to advanced broadband. A summary table is presented in (Table 3.11), including the combined definitions required for this study.

Table 3.11 Summary of capital definitions

Term	Definition	Literature
Human Capital		
Agency	Human agency & self-efficacy networked or collective agency, capacity to anticipate, strategize actions, capacity to maintain mobility and dynamism within social & physical structures	(Ashmore et al., 2017)
Digital Capital	Resources & benefits that can be utilised by communities, from Internet infrastructure to online information, models of communication and tools, to digital literacy & skills	(Roberts & Townsend, 2016)
Human capital - general	A unique set of skills, attributes & knowledge of an individual that contributes to productivity	(Schultz, 1961)
Human capital – ICT skills	The role of literacy in accessing ICT information – computer literacy & information literacy	(Díaz Andrade & Urquhart, 2009)
Human capital – ICT local leaders	Leadership from community entrepreneurs, their ability to engage and enthuse the local community and in some cases bringing external social capital networks and new skills & expertise	(Wallace et al., 2015)

Human capital – Mars summary	An individual's skills, experience, knowledge, satisfaction, health & wellbeing.	(Roche & Jakub, 2017)
Human capital – Mars - focus on employee	Involving the many factors that impact individual well-being in the workplace	(Roche & Jakub, 2017)
Technology capital	Knowledge to implement the physical network & links to other media	(Wallace et al., 2015)
	Other technical skills were defined as building work with the ability to cut trees, dig trenches to lay cables & ensure line of sight for wireless connectivity	(Wallace et al., 2015)

For purposes of this research, these definitions will be combined under the human capital banner, as they relate to skills, knowledge and personal attributes. Digital and technology capital can be combined under the skills and knowledge (or human capital) required to exploit NGA services. The term "agency" combines human & social capital constructs. For ease of analysis, and separation of terms, this terminology will not be used. Equally, human capital focusing on well-being in the workplace will be excluded.

Social Capital

Term	Definition	Literature
Social capital summary - general	The trust, beliefs, norms, rules & networks that constitute the value of relationships for collective action.	(McElroy et al., 2006)
Social capital - ICT	The critical ingredient for both external and internal networks – the ability to "bridge" social networks & knowing what people, skills & knowledge were required to do which tasks are a key aspect.	(Wallace et al., 2015)
Social capital - ICT	Developed through networking both on & offline (bonding and bridging)	(Townsend et al., 2016)
Social capital – Mars	Non-financial relationships that affect a person's well-being & prosperity	(Roche & Jakub, 2017)
Social capital – Mars business summary	The community level (or group) rather than at the individual level & is the second component, along with human capital, of how people can be valued as an asset	(Roche & Jakub, 2017)
Cultural Capital	Benefits derived from cultural goods, activities & participation, which can boost the prestige and competence of a community, having both material & symbolic value for those who can access them – can be tangible (architecture, artefacts) or intangible (stories, traditions)	(Roberts & Townsend, 2016)
Identity capital	Commitment to the community, a strong sense of loyalty & purpose to the community, and a desire for making them work	(Wallace et al., 2015)
Sense of Place	The sense of community bonds & cohesion (shared culture & vision) – access to community heritage & to engage in community dialogue	(Ashmore et al., 2017)

The summary definition for social capital will be used (e.g. the trust, beliefs, norms, rules & networks that constitute the value of relationships for collective action) (McElroy et al., 2006) because it encapsulates the primary concepts identified in the literature. Trust is identified as a CSF. Networks, both internal and external, are CSFs for neo-endogenous rural development and technology. The value of relationships as a non-financial good for collective action will be used, as it is a core concept to answer the RQs. Cultural capital, identity capital and sense of place are relevant and significant forms of capital in a local community context but are considered outside the scope of this thesis. The unit of analysis is the local community context but adding terms in addition to the four-fold benefits are not relevant.

Environmental Capital

Term	Definition	Literature
Environmental Capital – ICT	Teleworking reduces travel & carbon footprint	(Phippen & Lacohée, 2016) add government 2013 impact of bb study
	Social media reduces the need for travel	(Townsend et al., 2016)
	Electricity or energy efficiency	(Mickoleit, Reimsbach-Kounatze, Vickery, & Wunsch-Vincent, 2009)
	Negative EC - increased capacity impacts transportation, pollution & infrastructure needs – expansion of physical space	(Leong et al., 2016)
Environmental capital – Mars	Various natural resources we utilise in the production & distribution process – focus on inputs rather than outputs	(Roche & Jakub, 2017)

Environmental capital is not the primary focus of this thesis, but it has been identified as having positive and negative effects as a result of advanced broadband. Thus, it needs to be recognised in the study, as a common good and to address the sustainability debates regarding climate change. Questions will be incorporated to ask respondents what they think about this topic in relation to NGA services.

Shared Financial Capital

Term	Definition	Literature
Shared Financial Capital – ICT	Community-self funded model – fund-raising cash & volunteer labour	(Ashmore et al., 2017)
ICT community funding	Variety of resources rather than one financial source – from government, local authorities, agencies, charitable income & own investment	(Wallace et al., 2015)
	Understanding the blending of municipal, private & non-profit organisations that provide resources for community ICT development	(Wallace et al., 2015)
Examples of community funding model	Peninsula Village – from a private company to cooperative	(Wallace et al., 2015)
	Uplands Village – from cooperative to private company	(Wallace et al., 2015)
	Island Village – part of a regional social enterprise	(Wallace et al., 2015)
	Commuter Village – social enterprise but for how long?	(Wallace et al., 2015)
Shared financial capital – Mars	Take a fresh look at the way in which capital is generated & how it is shared among the various stakeholders – not only the shareholders but the various participating parties along the value chain	(Roche & Jakub, 2017)

The terms financial capital and shared financial capital (SFC) are relevant to this investigation. The combination of endogenous and exogenous capital infusions is required for community initiatives to be successful. The term shared financial capital is a more holistic and meaningful term that can hold all parties accountable versus a profit-only mentality that creates distrust and anger amongst communities.

3.6.7.1 Summary of capital definitions

In summary, the various capital definitions identified in the literature can be incorporated into the four-fold benefits derived from SFBB implementation, namely human, social, environmental and financial capital (Phippen & Lacohée, 2016; SERIO, 2015). Thus, the goal of this thesis is to encapsulate the rural broadband capital terminology into a relevant conceptual framework to be tested against the four-fold benefits of SFBB for rural communities.

3.7 Innovation Analysis (OBJ3)

As discussed in (Section 3.2.2) the innovation management (IM) literature was reviewed to identify new innovative alternatives to ICT supply and demand resolution (OBJ3). This section summarises the relevant concepts and predominant authors in the field. In addition, the core concepts identified in the rural broadband literature are discussed further in this section (e.g. collaboration, ecosystems, new business models, how to engage multiple stakeholders and the value of human & social capital).

Industry 4.0 and the implementation of NGA "full fibre & 5G" services into the rural community will bring "creative destruction" opportunities and challenges (Schumpeter, 1959) (Section 3.3.4). Whether or not rural communities will want these new technologies is to be determined. Nevertheless, 21st-century business is about opening up to new possibilities and capitalising on innovations for economic growth and individual and collective wellbeing (Chesbrough, 2012; Tidd & Bessant, 2009). IM studies discusses information knowledge flows relevant to the diffusion of technologies (e.g. gatekeepers, knowledge brokers & networks) (Section 3.3.5).

Moreover, critical success factors (CSFs) for ICT projects (e.g. product champions), multi-player engagement (e.g. collaborative efforts & systems integration), and the value of human & social capital (e.g. reconciling appropriability challenges and the sharing of assets & outcomes) will be discussed in this section. Previous rural broadband studies have started to incorporate open innovation frameworks and systems integration practices (Hosseini et al., 2018; Ramírez, 2007). Henceforth, IM studies have relevant concepts for this thesis.

This section is not an exhaustive literature review, but a snapshot of primary authors and concepts that can assist new ways of thinking about this evolving problem area. As explained in the introduction (Section 1.3), the IM concepts of open innovation (Section 3.7.1), co-creation (3.7.2) and multi-stakeholder engagement (Section 3.7.3) will be explored in this section.

Traditionally, IM studies focus on research and development (R&D) and how companies develop innovative products and services (Fagerberg, 2004; Fagerberg & Verspagen, 2009). Previously, R&D happened behind closed doors (e.g. to protect intellectual property & secure the value of the innovation), but because of ICT

diffusion, R&D processes have "opened up" to collaborations and the new opportunities available (Dodgson, Gann, & Salter, 2006). This new thinking was developed further by Henry Chesbrough (2006) who coined the phrase "open innovation". The quotation *"no matter who you are, most of the smartest people work for someone else"* is attributed to Bill Joy (co-founder of Sun Microsystems). The quotation is used throughout the extant IM literature because it best describes the motivation to "open up" to collaborative efforts and not stay locked behind "closed doors". Open innovation (OI) thinking is being promoted across sectors, inside and outside of companies, including governments, communities and individuals (Chesbrough, 2012; Jones et al., 2016).

3.7.1 Innovation management (IM) – Historical background

As explained in the introduction (Section 1.3) entrepreneurs and microbusinesses (MBs) are vital to the economy and need to be supported through innovation. The Economist Joseph Schumpeter in 1911 (1934 English translation) is said to be the founding father of innovation studies, or more recently an "innovation prophet" (Abrams, 2007; Croitoru, 2012) because his seminal work on the role of the entrepreneur has relevance today. Croitoru explains that "*The Theory of Economic Development*" (Schumpeter, 1959) was the first step to create the theoretical tools and concepts which were required to approach the economic sphere. Fagerberg & Verspagen (2009) explain that it was only after World War II and into the 1960's that Schumpeter's work on the subject started this revival in economic thinking as *dynamic* versus *static.* Schumpeter's concept was endogenous and the role of the entrepreneur to create the source of energy that fuelled the economy was apparently in contrast to the economic thinking of his time (p. 220). To explain it another way *"entrepreneurial actions are the main mechanism in the process of economic development, and the disturbance of the economic system is impossible without them"* (Croitoru, 2012, p. 141). Hence, the role of the entrepreneur is critical to economic development, particularly with ICT innovation and the impact in rural communities (Wilson et al., 2018).

Innovation studies as an academic field began to take root circa the 1960's with the creation of the United States Air Force Research and Development Corporation (RAND) in 1948 and the UK Science Policy Research Unit (SPRU) in 1965

(Fagerberg, Mowery, & Nelson, 2006). Fagerberg & Verspagen (2009) literature review of the new scientific field of IM studies, acknowledge the influence of RAND who produced some of the earliest IM scholars who contributed widely to the field. The authors (2009) cite some of the earlier topics and scholars, notably the work of Nelson, Arrow, Griliches, Rogers and Schmookler. Their work between 1957 and 1962 included: the success or failure factors of R&D innovation; the spread of innovations; sources of the invention and the allocation of resources to the generation of new knowledge (p. 220).

The creation of the UK SPRU in 1965 was significant in that it led to the formation of the journal "*Research Policy"* in 1972 (Fagerberg et al., 2006). The journal remains one of the most influential innovation publications today (Biemans, Griffin, & Moenaert, 2007; Fagerberg & Verspagen, 2009; Rigby, 2016; Shafique, 2013; Thieme, 2007). The advent of RAND and SPRU, as centralised hubs, helped lay the foundations of scholarship in both the role of human capital and the spread of the networks (e.g. social capital) across North America and Europe (Fagerberg, Fosaas, & Sapprasert, 2012; Thieme, 2007).

Another notable observation is the cross-disciplinary nature of innovation research. Economics is not a solitary discipline when investigating the IM phenomenon, because the generation and impact of innovation affects engineering (e.g. infrastructure, technology), geography studies (e.g. clusters & networks), management (e.g. new products, process & service development), organisational studies (e.g. new business models), psychology (e.g. entrepreneurs, motivation) and sociology (e.g. people, society) (Damanpour, 1991; Shafique, 2013). Shafique (2013) literature review investigates the multidisciplinary IM approach through four of the major social science disciplines: economics, management, psychology and sociology. The author (2013) argues a recent shift in IM studies, whereby economics is taking a more insular approach, which is moving economics away from management and sociology. In Shafique's view (2013) this kind of isolated thinking and self-referencing within the academic domains will not add but subtract to the exploration of IM studies, which is inherently cross or multidimensional (p. 76).

Moreover, a new economic team has emerged to challenge the status quo on business studies at the University of Oxford (Said Business School, 2017a). Roche &

Jakub (2017) are challenging businesses to innovate their business and economic models. The authors (2017) argue that the economist Milton Friedman's 1970 statement that the sole responsibility of business is to maximise profit for shareholders has driven the mantra of business studies over the past 50 years. The statement has been a valid driver of business but indicates that the only metric to measure business success is financial. The authors (2017) argue that business can be mutually beneficial, and the metrics of business can be more than mono, but multiple. The metrics can include human, social and environmental capital as well as financial. This mutually beneficial methodology is a more holistic and productive way to approach business in the 21st-century (Said Business School, 2017a). This kind of economic thinking is on par with the changing innovation frameworks and can provide a cross or multi-disciplinary approach to maintain the academic integrity of IM studies required for this thesis.

Some other relevant and influential studies and concepts that have evolved from 1960-2017 and are still debated today include:

Information and knowledge flow – inside and outside of the firm (Allen & Cohen, 1969; Von Hippel, 1978). Thomas Allen's influential work investigated the geographic proximity of R&D installations and how the interaction between facilities helped create information or "knowledge flow" (Allen & Cohen, 1969). Attention was given to individuals who observed what was happening around them internally or externally to the firm. Allen labelled these people "gatekeepers" and the communication flows that go through them assist with the internal and external flow of innovation knowledge. This work is also a premise to the open collaboration framework, and the "gatekeepers" are still relevant to enable the successful flow of networks (e.g. value of human & social capital). The value of gatekeepers and knowledge brokers is confirmed in the Peru study on ICT diffusion in remote rural communities (Section 3.5.1).

Success and failure of R&D innovation – the famous SAPPHO project (Rothwell et al., 1974) concludes that innovation is a "multifunctional process" and successful innovators look at the complete range. The author concludes the factors for successful innovation are to focus on user needs, good communication and market intelligence, and the presence of a "Product Champion" (p. 289). These findings are comparable to

the community-led initiatives and the neo-endogenous networks required for rural development (Section 3.5.1).

Appropriability challenges - or how to capture value or profit from innovation (Teece, 1986, 2006) is an enduring debate that continues today. Teece (1986) found that it is not always the innovator who profits from the innovation. In comparison, Von Hippel (2005) found it is not always financial metrics (or pecuniary measures) that are the most significant motivators for innovation. Thus, the appropriability challenge needs to be discussed and managed for the benefit of all stakeholders.

System innovation – Rothwell (1994) describes the evolution of innovation processes by recounting the economic changes throughout the generations based on supply and demand:

i. First generation (1G) or "technology push" (the 1950s – mid-1960) is where new technologies provided new products and created a "supply side" where the technology "pushed" the demand. This was after World War II, and these new technologies created jobs and wealth.
ii. Second generation (2G) reflects the changes in the market. As society remained affluent, the competition for supply-demand equalised, so marketing became a factor to innovate. The "market-pull or need-pull" (the mid-1960s - early 1970s) is when companies started focusing on the "demand side" of innovation through market research.
iii. Third generation (3G) is defined by a recession and the need for companies to adopt new strategies as supply outstrips demand. The adaptation is to become more interactive or "coupling" process (the early 1970s – mid-1980s). The process is more general, combined technology capabilities and market needs, and introduced feedback loops to manage the process. This differentiated it from a simple (or linear) "supply and demand" model to one that is more interactive and "couples" both.
iv. Fourth generation (4G) "integration & parallel" process (the early 1980s – early 1990s) was influenced by the speed and efficiency of Japanese manufacturers. Their approach was a "rugby" style of integrating the different departments and managing the process in parallel throughout product cycle.

v. Fifth generation (5G) is described as "systems integration & networking" (the late 1990s – onward). It continues the 4G innovation process, but with increased efficiency due to ICT communications.

These iterations are relevant to this thesis as the "coupled approach" and "systems integration" to evaluate supply and demand are being incorporated into rural broadband studies (Hosseini et al., 2018; Ramírez, 2007; Wallace et al., 2017).

3.7.2 Open innovation (OI) – Human & social capital engagement

Open innovation (OI) is a phenomenon that has changed the way people and organisations think (Chesbrough, 2017; Dodgson et al., 2006; Enkel, Gassmann, & Chesbrough, 2009; Gassmann, Enkel, & Chesbrough, 2010; Lichtenthaler, 2011; West et al., 2014). OI is not a new phenomenon because the use of internal and external networks for collaboration and sourcing information has existed throughout IM studies (Allen & Cohen, 1969; Huizingh, 2011; Trott & Hartmann, 2009; Von Hippel, 1978). The term open innovation has captured the imagination of organisations and is considered a fait accompli for the 21st-century thinking (Lichtenthaler, 2011; West et al., 2014).

OI, by its nature, can be considered human & social capital engagement, because bonding (internal relationships) and bridging (external relationships), knowledge transfers and trust are fundamental concepts in both human & social capital theory (Section 3.6.3). OI thinking as a concept to "collaborate outside the box" is relevant to this thesis.

3.7.3 Co-creation – Human & social capital engagement

Another notable and influential concept in the IM literature is user or co-creation innovation. Both concepts can be considered human & social capital engagement because they rely on the individual and corporate users' education, skills and tacit knowledge to find solutions to utility problems.

If Chesbrough (2006) is recognised as the founder of open innovation, then Eric Von Hippel (2005) is acknowledged as the founder of user or co-creation innovation. The extant user innovation literature over the past 30 years credited Von Hippel's work when this new stream of research emerged (Bogers, Afuah, & Bastian, 2010; Gamble, Brennan, & McAdam, 2016; Trott, Duin, & Hartmann, 2013).

Von Hippel argues that this shift from producer-only (or supply-side) design to open and collaborative co-creation (or demand-side) design has democratised innovation (Von Hippel, 2005). One of the key arguments Von Hippel (2005) makes is the benefits of appropriability (or value) are not always financial. Von Hippel (2011) suggests producers who choose to "free reveal" their innovation can derive benefits from non-financial measures. Incentives and motivations can include reputation enhancement, positive network effects with the diffusion of their innovation and fewer costs associated with new suppliers or the absence of legal costs (p. 6).

Rural community-led broadband can be viewed as user innovation and co-creation. Local digital champions (LDCs) use their IT skills to "do it yourself" (DIY) for the community (e.g. human capital & non-financial motivation). The community volunteers cut costs by digging trenches and waiving way leaves (e.g. social capital & non-financial motivation). Hence, user and co-creation innovation can be viewed as human & social capital engagement. All stakeholders in the local community ecosystem need to understand the value in non-financial motivations, because they are fundamental in resolving the digital divide (Section 3.5.1).

3.7.3.1 New business models

Another notable concept in the future of OI includes business model innovation. These models include multiple collaborations, communities and entire ecosystems (Chesbrough, 2017, p. 35). Developing new business models and capabilities *is* innovation and can lead to competitive advantage (Chesbrough, 2010; Teece, 2010). Chesbrough (2010) advocates that although business model innovation is difficult, the barriers of confusion or obstruction can be overcome via a *"commitment to experimentation"* (p. 359). Chesbrough concludes that business model innovation is vital but difficult to achieve. Despite the challenges and barriers, organisational processes need to change, and the right attitudes towards adopting change can also be addressed through experimentation (p. 362). Developing new or alternative business models is required in the rural broadband literature (Section 3.5.1) and the WEF recommendation (Section 3.6.2).

The introduction of the Mutual Business forum, developed by Mars Corporation and the University of Oxford, is creating a space for organisations to innovate and experiment with a new business model and economic framework (Roche & Jakub,

2017). Admittedly, Mars Corporation has an almost ideal ecosystem from which to test this new economic model, but the concepts can be applied to other business arenas. Due to the nature of the business, Mars operates in developing countries where local communities have not always been treated fairly. The value distribution has not been equally shared amongst all the stakeholders in the ecosystem. The same can be said about the rural-urban digital divide. Nevertheless, the Mutual Business model is different. It is challenging organisations "up front" to take a *counter-intuitive* approach to business. It is challenging 21st-century businesses to consider the whole of the ecosystem and analyse the *pain points* as a means of considering how to add and distribute value amongst all the stakeholders in the ecosystem from the outset. The mutual business approach uses the hybrid-value system (HVS) defined previously as *"an ecosystem that relies on connecting the core assets of several stakeholders"* (Section 2.2.4, Table 2.2). The approach is a radically new way of considering how to evaluate innovation within a business model context. Local governments cannot distribute money in subsidies without business and community engagement. It is this kind of innovative thinking and providing the "how" organisations can approach challenges, which makes Mutual Business a new and measurable prospect.

Tidd & Bessant (2009) suggest the 21st-century innovation landscape is not about one organisation and describe it as an increasingly multi-player game where organisations of every shape and size work together in networks. The multi-player game perspective needs to adopt a *systems view* to include other players (Section 3.3.5). Consumers and suppliers, competitors and collaborators, create an ecosystem where innovation takes place (p. 70). Thus, Roche & Jakub (2017) argue a *"new multiple-capital business model can create and harvest the true riches of a new century - a model that leverages the principles of mutuality (the sharing of benefits) as a driver of value creation – enhancing the hidden riches in the ecosystems which businesses operate"* (p. 18). These innovative concepts are an essential context to explore the challenges faced by rural community stakeholders.

3.7.4 Multi-stakeholder engagement

Multi-stakeholder engagement is another challenge. Previous literature in this field focuses on how ICT companies can partner with users to create and develop new

products and services. Thus, the focus is on how companies engage users, but the concepts of how to engage a multi-stakeholder context can be reviewed.

3.7.4.1 Previous ICT co-creation models

In a 2009 literature review (Pascu & Van Lieshout, 2009), the authors examine how user-centric services can be a catalyst for promoting future services over next-generation networks (NGN) (p. 82). The authors explore three contemporary approaches to user-centric or co-creation innovation: living labs, open innovation and social computing. They describe living labs as "citizen-firm" collaborations, open innovation as "firm" innovation (Chesbrough), and social computing as "citizen" innovation (Von Hippel). The authors review the three innovative approaches. Open and user innovation have been explained (Section 3.7.2 & 3.7.3). Thus, the focus will be on living labs.

3.7.4.2 Living labs

Living labs is a concept to combine multiple players into an ICT innovative context. Pascu & Van Lieshout (2009) describe living labs as user-centric and co-creation innovation because users play a prominent role as co-designer or co-producer and become part of a public-private partnership (PPP). The engagement can be with industry, government, or all three. These PPPs can be created with a specific purpose and can include a social dimension. Often local authorities or governments want to encourage innovation, especially if it can help solve social dilemmas or challenges. Living labs are designed to engage technological and socio-economic factors. Living labs are innovation arenas involving multiple stakeholders. Pascu & Lieshout (2009) combine other research to place living labs amongst in-house R&D and pilot schemes, by showing how living labs can sit between these two concepts in an open innovation (OI) platform. For example, prototyping, field trials, and test beds are often organised by in-house R&D trials. Pilot schemes are taken out to the market and tested as societal or market pilots. Living labs sit between these two options, as the opportunity to combine both into an OI platform (p. 86). The living lab literature in 2008 lacked studies in processes and methods. Nonetheless, it was considered to have potential for ICT research and to develop a framework in which to *manage multiple stakeholders*.

Schuurman (2015) aims to bridge the gap between OI and user innovation by combining these methods into the living labs context. The author focuses on the

enthusiastic European adoption of the living lab concept and its subsequent growth and decline since 2006. Schuurman makes a principal observation that the current living lab literature is not well developed in academic impact. Nevertheless, Schuurman's research argues by combining open and user innovation theoretical concepts could bridge this gap. The author makes a helpful contribution by organising living labs into a three-way model (p. 316) summarised in the following (Table 3.12).

Table 3.12 Schuurman's living lab three-way model

Macro-level	Consisting of a constellation of public-private partnerships as open innovation: knowledge transfer between organisations.
Meso-level	Project level as open and user innovation: characterised by active user involvement, co-creation, multi-method & multi-stakeholder.
Micro-level	Methodology of different research steps as user innovation: user involvement & contribution to innovation.

Without an in-depth study into the European Network of Living Labs concepts or its record of success and failures, it is difficult to assess if this is a viable concept for this thesis, even though it contains the core concepts of a multiplayer, multi-stakeholder arena for open and co-creation innovation. The amalgamation of the macro-level knowledge transfer between PPPs, meso-level (project level) for co-creation and multi-stakeholder, and micro-level (methodology) of community involvement is relevant to this study.

3.7.4.3 Value of human & social capital in living labs

A 2014 comparative view of living labs with users at home (Ley et al., 2014) revealed some relevant results for this thesis. The comparison is between two longitudinal living lab studies of ICT research in Lancaster, UK and Siegen, Germany. The four-year study reviews the success and failure of the methodologies and user engagement, but of interest is the human & social capital, and how it played out in both scenarios. In Lancaster, the University had a long-standing relationship with a rural village that acted as a test bed for multiple research activities. The relationship was not brokered by the University, but by a woman living in the village whom they named "Carol". This "gatekeeper" acted as their long-term mediator and social cohesion trouble-shooter throughout the ten-year relationship between the rural village and the University. "Carol" had heard the rural village could obtain subsidies for broadband

provision if they were willing to be involved in research trials. Although this was the initial incentive for "Carol" to approach the University, her involvement throughout the ten-year period was voluntary (non-pecuniary). When asked about her commitment, she said she enjoys the mediator role and playing a part in the community. In contrast, the German experiment was more formally organised, and ran into trouble because the relationships were not developed and lacked trust and social cohesion. The value of human & social capital was evident when it came to motivating users and keeping the project going over the four-year period. These are valuable examples and illustrations of non-financial measures, but highly relevant to the success, and failure, of research projects and investment.

3.7.5 Summary of Innovation Analysis

In summary, the IM literature reveals relevant concepts and frameworks. The non-financial value of human & social capital (e.g. gatekeepers, knowledge brokers, product champions) are considered critical success factors (CSFs) akin to the rural broadband literature (Ashmore et al., 2017; Wallace et al., 2015). The value of open innovation (OI) and co-creation by bringing together organisations (endogenous) and users (exogenous) is evidenced throughout the extant literature (Chesbrough, 2017; Halseth et al., 2019; Von Hippel, 2005). The challenges of multi-stakeholder engagement with living labs to resolve ICT innovation and community dilemmas is relevant to this thesis. The aim therefore is to select or customise the right framework to organise and measure multi-capital, multi-stakeholder cooperation across the stakeholder ecosystem to mutually resolve rural community NGA supply and demand challenges.

3.8 Conceptual framework

Jabareen (2009) defines a conceptual framework as *"a network or 'plane' of interlinked concepts that together provide a comprehensive understanding of a phenomenon or phenomena"* (p.50). Instead of description and theme identification, the aim of building a conceptual framework is embodied in the concepts (theoretically identified) and subsequent relationships. Ravitch & Riggan (2016) define a conceptual framework as an argument about *"why the topic matters and why the means proposed to study it are appropriate and rigorous"* (p. 5). Maxwell (2012) explains the function of the conceptual framework is to inform the research design and assist in refining research goals (e.g. why is this study worth doing, what issues do you want to clarify) and questions (e.g. what do you want to better learn and understand) (p. 4). To answer these questions, and develop the conceptual framework, the concepts and gaps identified in the literature will inform the research design relevant to answering the RQs.

The integration of the core concepts are required to provide understanding and meta-synthesis for the conceptual framework (Jabareen, 2009). Thus, the following (Sections 3.8.1-3.8.7) will summarise the core concepts to inform the conceptual framework (Section 3.8.8).

3.8.1 Core concepts – Academic field – Complimentary theories

Ravitch & Riggan (2016) state the conceptual framework is a lens or set of lenses for making sense of things and *"most useful when it incorporates complimentary theories that capture different aspects of the subject"* (p. xii). Hence, the combination of economic theories (e.g. neo-endogenous or NED), local geographic theories (e.g. local milieu/place-based) and sociology (e.g. resilience theory) are a network of interlinked concepts for this thesis (Section 3.2.4).

One of the contributions to knowledge is to add to the existing theoretical research within the rural community-led broadband domain. As previously explained (Section 3.5.1), neo-endogenous economic development (NED) approach engages local and external stakeholders in a rural community context (Salemink & Strijker, 2016). Resilience theory, as developed by Ashmore (2015) for rural SFBB impact analysis, incorporates agency (or human capital), capitals as resources (e.g. leadership or

human, social & financial capital & so forth) and sense of place (specific community or location) (Section 3.5.1). Terluin's (2003) explanation of the mixed exogenous/endogenous (or NED) rural economic growth strategy, includes the territorial innovation model which combines local milieu (place-based) theory with the diffusion of innovation (Section 3.2.4.1, Table 3.6). Thus, making NED a relevant theoretical construct for this study.

Salemink & Strijker (2016) identified the key to successful broadband initiatives resides in the cooperative interplay between the various stakeholders and to focus on the mutual learning of both supply and demand actors (Section 3.5.1.1). The World Economic forum (The Boston Consulting Group, 2016) action plan equally identified multi-stakeholder cooperation and coordination to address underlying local environments and barriers as vital to developing best practice (Section 3.6.3). A business ecosystem resembles an ecological ecosystem because of its "complex interdependent parts" (Section 2.2.4). Hence, the conceptual framework will be broken into three sections to provide a diagram of each ecosystem and how they will relate to one another. These ecosystems include exogenous stakeholders (e.g. supply actors), endogenous stakeholders (e.g. demand actors) (Section 2.3) and the related capitals, barriers, drivers and opportunities for each (Section 3.6). These then combine into a NED approach to focus on the Hybrid Value System (HVS) that is defined *"as an ecosystem that relies on connecting the core assets of several stakeholders"* (Section 2.2.4, Table 2.2 & 3.8.8.1, Table 3.13).

3.8.2 Core concepts - Rural BB (OBJ1A, B & C)

The rural broadband literature identified neo-endogenous (NED) case studies, success and failure factors in community-led initiatives (OBJ1A). *Critical success factors* (CSFs) included human capital (e.g. leadership, skills & knowledge), social capital (e.g. local networks & trust in community) (Section 3.5.1.2.1). *Failure factors* included lack of human capital (e.g. deficient financial & technical skills), lack of trust amongst commercial stakeholders, and failure of local government to allocate funds (Section 3.5.1.2.2). New opportunities included *Altnets* who favour strategic partnerships and innovative business models (Section 3.5.1.2.3). To bridge the digital divide, *rural partnership* and *new business models* is suggested as an act of bringing together public and private resources (Section 3.5.1.3.1). Moreover, open innovation

(OI) integrated place-based (e.g. local milieu) approaches (Hosseini et al., 2018) and innovative ecosystems, stakeholder collaboration and co-creation are suggested to develop innovation (IM) opportunities at the local-level (Section 3.5.1.3.2).

Supply studies (OBJ1B) were summarised by the influx of rural gigabit funding, the growing number of Altnets, the barrier busting taskforce, the development of creative business models and strategic partnerships, local authority engagement and introduction of new technologies (e.g. TV whitespace) to help bridge the digital divide (Section 3.5.2.2.1). *Demand studies* (OBJ1C) were summarised by the factors to stimulate adoption and the engagement of local community capital is encouraged (Section 3.5.2.3.1). *In-between supply and demand studies* (OBJ1B&C) were summarised by the need and use of SFBB in rural communities had individual, business and community resilience impacts to reduce outmigration. Evidence of environmental capital (e.g. social media marketing reduced travel) and non-financial value-add through creative microbusinesses (MBs) are required to develop rural capital assets (e.g. human, social, environmental & financial) (Section 3.5.3.3). *Recent FTTH, NGA and UFBB studies* (OBJ1B&C) were summarised by more cost-benefit analysis of full-fibre government subsidies but the EORN (Eastern Ontario Rural Network) case study in Canada revealed four-fold capital benefits for eco-innovative farms, SME's and community organisations (Section 3.5.4.1). Thus, these interlinked concepts provide a comprehensive understanding of the digital divide and will form part of the conceptual framework.

3.8.3 Exogenous supply stakeholder ecosystem (OBJ2A, B & C)

The *exogenous supply stakeholder ecosystem* includes the UK Government, Welsh Government and local authorities (Section 2.3.1 – 2.3.3). The commercial suppliers include Openreach and the Altnets identified in (Section 2.3.4 & 2.3.5).

Drivers and opportunities for Industry 4.0 supply (OBJ2A) include the governments "full fibre & 5G" ambitions for Internet of Things (IoT), GDP growth, job creation, SME revenue growth and quality of life (e.g. agriculture, education, financial services & health) (Section 3.6.1).

Drivers and opportunities for supply (OBJ2B) implementation include a more collaborative approach for new business models and barrier busting initiatives at local

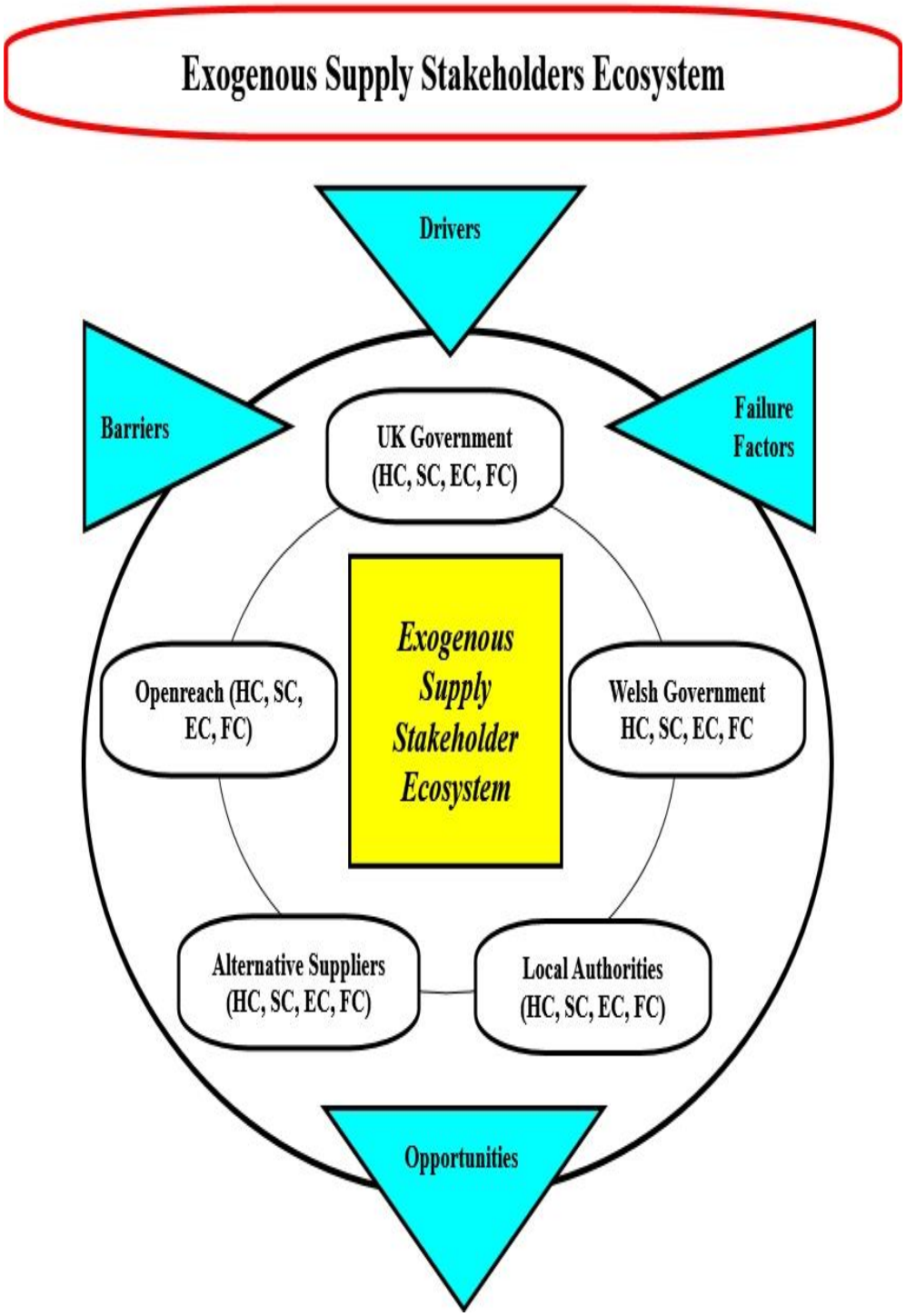
level (Section 3.6.2). Moreover, state-aid funding should include assistance for local communities to access and allocate funding opportunities and the value of social capital to target and disseminate funding (Section 3.6.2.1.1). Notably failure factors for rural community state-aid funding included lack of human capital skills (e.g. funding application knowledge), bureaucracy, compressed timelines and lack of community engagement to include adoption stimulation alongside supply initiatives (e.g. chicken & egg scenario of supply & demand initiatives should be considered together in rural communities).

Barriers to government supply (OBJ2C) include cost, geography, return on investment (ROI), rolling out the backbone, high prices and lack of competition (Section 3.6.3). *Barriers to commercial supply* include cost, geography, low population density, investment incentives and ROI. Barriers to supply can be summarised as constraints to financial capital (e.g. costs), human capital (e.g. lack of skills, knowledge & so forth), social capital (e.g. low population density & community leadership) and environmental challenges (e.g. geography) (Section 3.6.3.1). *Supply failure* factors in rural communities includes distrust of commercial suppliers and government, lack of human capital (e.g. no technical expertise or negotiating skills), misallocation of funds, negative social capital (e.g. lack of bonding relationships & bridging networks) and potential power plays (Section 3.5.1.2.2). Communities with low human, social and financial capital will struggle if outside rural gigabit catchment area.

The identification of the *four-fold capitals* (positive & negative), the level of skills, knowledge (human capital), and the value of networks (social capital) needs to be examined and analysed (Section 3.6.5.1, 3.6.6.2 & 3.8.7).

Finally, take-up of rural broadband requires local engagement (Section 3.5.2.3.1). Hence, supply stakeholders must work with local communities to overcome the demand barriers in the endogenous ecosystem (Section 3.6.3.1). Thus, these interlinked concepts provide a comprehensive understanding of the digital divide and will form part of the conceptual framework. A diagram of the interdependent relationships and capitals to be explored in the exogenous supply ecosystem are shown in (Figure 3.3).

Figure 3.3 Exogenous supply rural stakeholder ecosystem



**Core Concepts from Section 3.8.1, 3.8.2, 3.8.3, 3.8.5, 3.8.6 & 3.8.7. Capitals as assets & resources - human (HC), social (SC), environmental (EC) & financial capital (FC).*

3.8.4 Endogenous demand stakeholder ecosystem (OBJ2A, B, C & D)

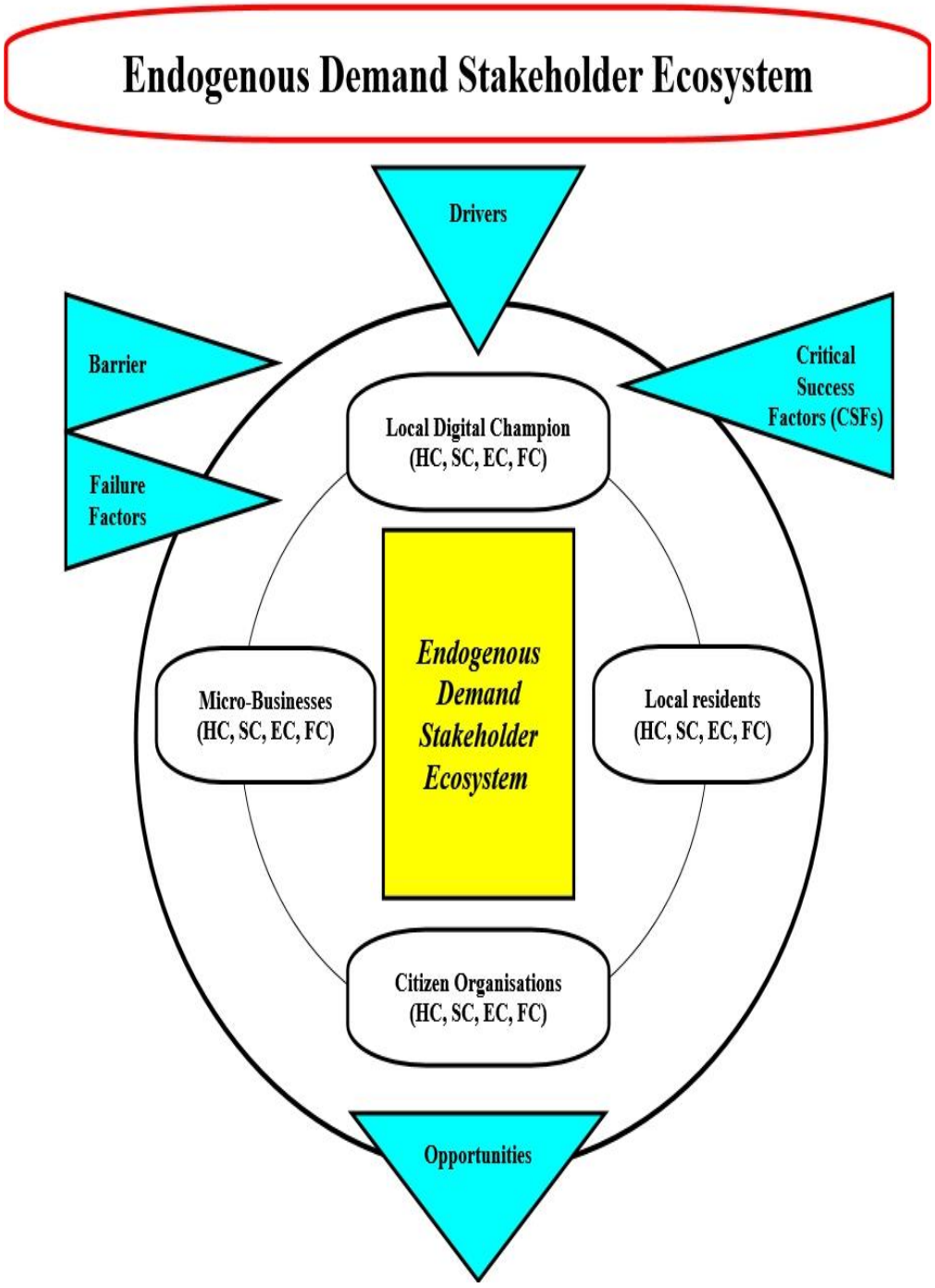
The rural community *endogenous demand ecosystem* includes local digital champions (LDCs), the local community, MBs and citizen service organisations (CSO) identified in (Section 2.3.6).

Drivers and opportunities for Industry 4.0 demand (OBJ2A) include education, enabling and supporting economic transactions, removing geographic limitations on communication, telehealth, teleworking and providing NGA innovation opportunities (e.g. Agri-tech & precision farming) (Section 3.6.1). *Drivers and opportunities for demand* (OBJ2B) include training incentives, IT Clubs, clawback clause for community re-investment and proactive approach by local authority to combine supply and demand aggregation (Section 3.6.2 & 3.6.2.2.1).

Barriers to community demand (OBJ2C) include commitment, finances, government failings, lack of leadership, skills and the scale, scope and perseverance to overcome supply barriers (Section 3.6.1). *Barriers to individual demand* include affordability, age, cost, education, lack of skills, motivation, low awareness and low perceived value of benefits (Section 3.6.3 & 3.6.3.1). The c*ritical success* (CSFs) and *failure factors* (OBJ2D) in community-led initiatives were identified in (Section 3.6.4 & 3.8.2). Thus, these interlinked concepts provide a comprehensive understanding of the digital divide challenge and will form part of the conceptual framework.

In addition, the identification, value and interplay of the *four-fold capitals* in endogenous ecosystems are more recognisable, particularly in light of investment (e.g. social fertility analysis) (Section 3.6.7 & 3.8.7). However, rural capitals need to be evaluated in relation to NED networks and the requirement for return on investment (ROI). A diagram of the interdependent relationships and capitals to be explored in the endogenous demand ecosystem are shown in (Figure 3.4).

Figure 3.4 Endogenous demand rural community ecosystem



**Core Concepts from Sections 3.8.1, 3.8.2, 3.8.4, 3.8.5, 3.8.6 & 3.8.7. Capitals as assets & resources - human (HC), social (SC), environmental (EC) & financial capital (FC).*

3.8.5 Core concepts – Innovation Analysis - IM literature (OBJ3)

The IM analysis (OBJ3) identified 21st-century business to include creative destruction innovation, dynamic ecosystems, knowledge flow, product champions, gatekeepers, knowledge brokers, bridges, networks and systems integration (Section 3.3.5 & 3.7).

Open innovation (Section 3.7.2) use of internal/external networks. Human and social capital (e.g. individual & corporate skills, knowledge, bonding, bridging & trust) are required to collaborate "outside the box" for co-creation and user innovation opportunities (Section 3.7.3). However, benefits are not always financial and the appropriability conundrum or "who profits" from innovation is yet to be reconciled. User innovation can be described as the local community, local digital champions (LDCs) and the willingness to dig ditches and so forth. More specifically, the creation of new business models to include *"multiple collaborations, communities and entire ecosystems"* are suggested for competitive advantage (Chesbrough, 2017, p. 35) (Section 3.7.3). The mutual business HVS approach is a new multi-capital, multi-stakeholder business model which aims to capture these concepts in a novel counterintuitive approach for 21st-century business (Section 3.7.3.1). Nevertheless, multi-stakeholder engagement is a challenge to combine IM opportunities (Section 3.7.4). Users play a prominent role as co-designer or co-producer and become part of a public-private partnership (PPP) (Section 3.7.4.2). The multi-stakeholder engagement can be with industry, government or all three. Schuurman's (2015) three-way model suggests macro-level knowledge transfer between PPPs, meso-level (project level) for co-creation and multi-stakeholder, and micro-level (methodology) of community (user) involvement which are relevant concepts for this study (Section 3.7.4.2, Table 3.12). Thus, all of these interlinked concepts provide an understanding of the IM opportunities available to bridge the digital divide and will form part of the IM analysis.

3.8.6 Core concepts – Human & social capital theory

Human & social capital are critical success factors (CSFs) across all domains: the academic field (Section 3.2.4), rural broadband (Sections 3.5 & 3.6) and IM literature (Section 3.7). Thus, providing the theoretical underpinning of this research (Section 3.6.5 & 3.6.6).

Human capital is tied to community-led economic development and creative destruction opportunities (Section 3.6.5). Social capital can have positive and negative impacts (Section 3.6.6). For example, if the trust quotient is high in a community, this impacts investment. Therefore, capital can be either valued and invested or lost and squandered (Section 3.6.5 & 3.6.6).

Flora (2016) defined capital as *"resources capable of producing other resources*" (Section 2.3.3). Lin (2002) defined capital as *"investment of resources with expected returns in the marketplace"* (Section 3.6.4). Thus, the investment of capitals to produce other capital and expected returns in the marketplace are interlinked concepts to provide an understanding of how to bridge the digital divide and will form part of the conceptual framework.

3.8.7 Core concepts - Four-fold capitals – Inputs/outputs

Clarification is required to separate what is meant by four-fold capitals (e.g. human, social, environmental & financial capital) as *assets and resources (inputs)*, versus the four-fold capital *benefits* identified as an *outcome (outputs)* of SFBB access in rural communities (Section 2.2.5).

The *four-fold capitals* identified in (Section 3.6.7) are assets and resources that need to be uncovered and analysed in both the supply and demand ecosystems. The four-fold capital assets identified in the literature need to be assessed if NGA is to have its desired effect or not. Thus, the four-fold capitals as assets and resources are considered an *input*, whereas the four-fold capital benefits as a result of NGA are considered an *output* will be differentiated as such in the conceptual framework (Figure 3.5 & 3.6).

3.8.8 Conceptual framework – Neo-endogenous (NED) approach (OBJ1-3)

The conceptual framework captures and combines these interlinked core concepts (3.8.1 – 3.8.7) to provide a comprehensive understanding of the digital divide into a NED ecosystem for analysis at the local level. This is to fulfil the research gap identified in (Section 3.4.1). Nevertheless, there is one final consideration on how to approach a rural community for digital development.

3.8.8.1 How to engage rural community digital development?

The final consideration related to the literature is how to engage rural community digital development. The "intelligent or smart" community development frameworks

are useful templates to identify processes and methodologies used to engage and map assets within a rural community (Section 3.5.1.3). The following table summarises the various frameworks (Table 3.13).

Table 3.13 Summary of rural community development processes

	Intelligent Community Development (Rural broadband literature)	**SWOT* Analysis** (Rural broadband literature)	**Open Innovation Process** (Rural broadband & IM literature)	**Mutual Business Process** (IM literature)
Country	USA	Australia	EU	UK
Author	(Gallardo, 2018)	(Alam et al., 2018)	(Hosseini et al., 2018)	(Roche & Jakub, 2017)
Key Principle	Increasing awareness of helping rural communities' transition to digital age.	Matching a regions resources & capabilities to the competitive environment in which it operates.	To incorporate the various local stakeholders & local contextual factors to discover relevant digital solutions for smaller population.	Product to "final few" & hard to reach areas. Adopting a more holistic approach to engage local stakeholders upfront.
Time Frame* depending on scope& goals	Longitudinal	Cross-Sectional	Longitudinal	Cross-Sectional
Methodology	Engaging with the community, mapping assets after community buy-in, implement & document the actionable goals and assign responsible parties, & recognition through the Intelligent Community Forum (ICF) awards programme.	Used social cognitive theory & UTAUT survey to gather data. This data was translated into a SWOT analysis strategy for digital engagement.	Open Innovation Framework - to engage local communities in developing smart town digital engagement - uses inside out; outside in & coupled OI approach.	1. Hybrid Value System (HVS) assessment of all stakeholders. 2. Social capital assessment. 3. Training & awareness of product to a hard-to-reach area. 4. Develop & measure human & social capital contribution.

Suitability to answer RQ	No – timeframe doesn't allow.	Partially – maps area but lacks strategy to engage stakeholders.	Yes – engaging community to map digital assets, but time constrained.	Yes – product to a hard-to-reach market strategy.

**SWOT – strengths, weaknesses, opportunities & threats*

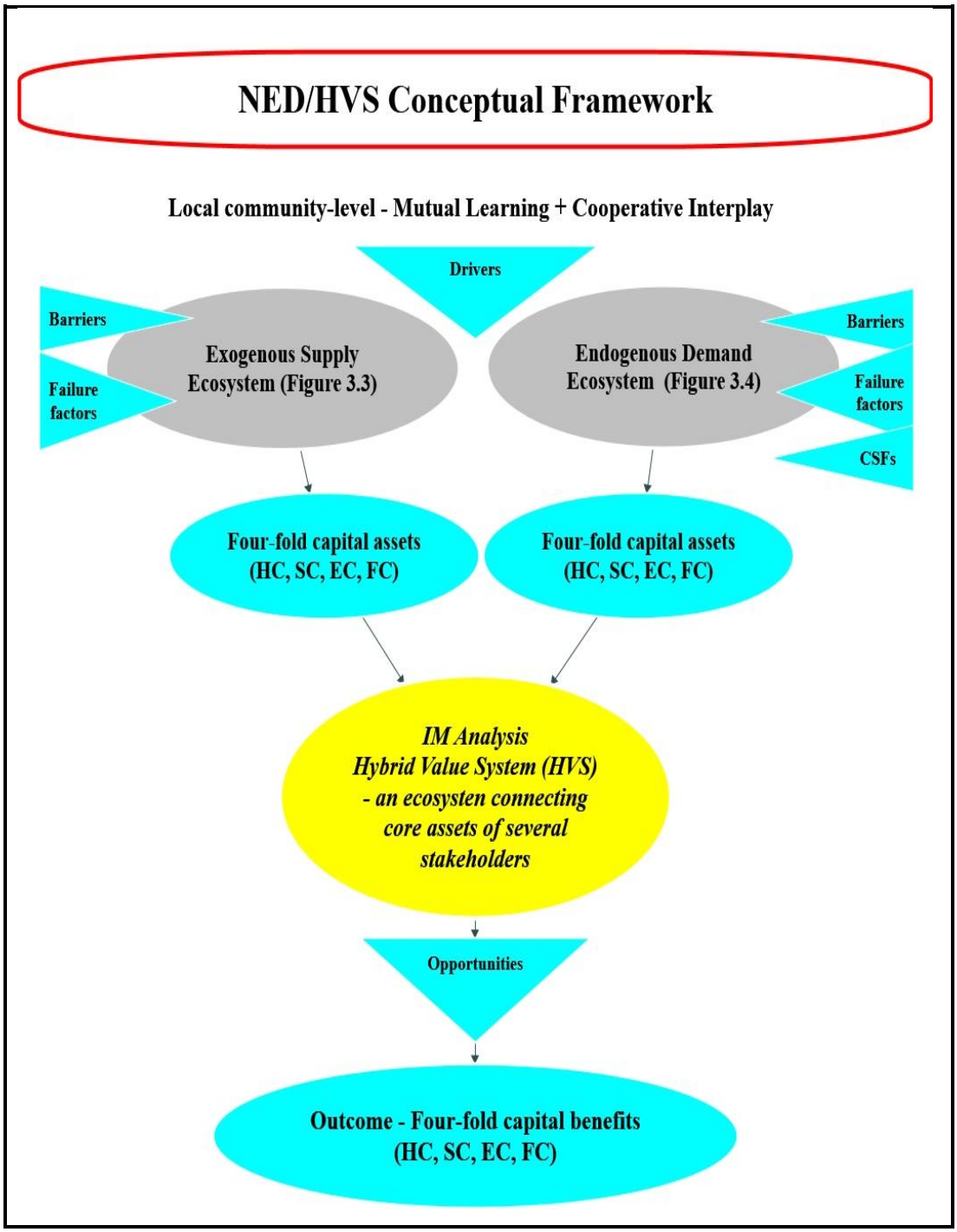
In summary, due to time constraints the longitudinal frameworks were not permissible. If time had allowed the Open Innovation process could have been considered because of the inside/out local stakeholder analysis. Nonetheless, the cross-sectional timeframes were considered. The SWOT analysis maps the area but lacks a strategy to engage stakeholders. Therefore, the IM mutual business process was considered the most appropriate approach given the timeframe and the product to final few market strategy. In addition, the mutual business approach values the four-fold capitals up front in the business model which makes it a complimentary concept to this study (Section 3.7.3.1).

3.8.8.2 NED/HVS Conceptual Framework

The aim of the conceptual framework is to combine both exogenous supply (Section 3.8.3, Figure 3.3) and endogenous demand (Section 3.8.4, Figure 3.4) ecosystems into a neo-endogenous (NED) approach (Section 3.8.8, Figure 3.5). The innovation management (IM) mutual business Hybrid Value System (HVS) is a core construct for evaluating both supply and demand four-fold capitals and will be used for further exploration in this thesis (Figure 3.5).

Figure 3.5 Conceptual framework for NED/HVS approach

Local community ecosystem



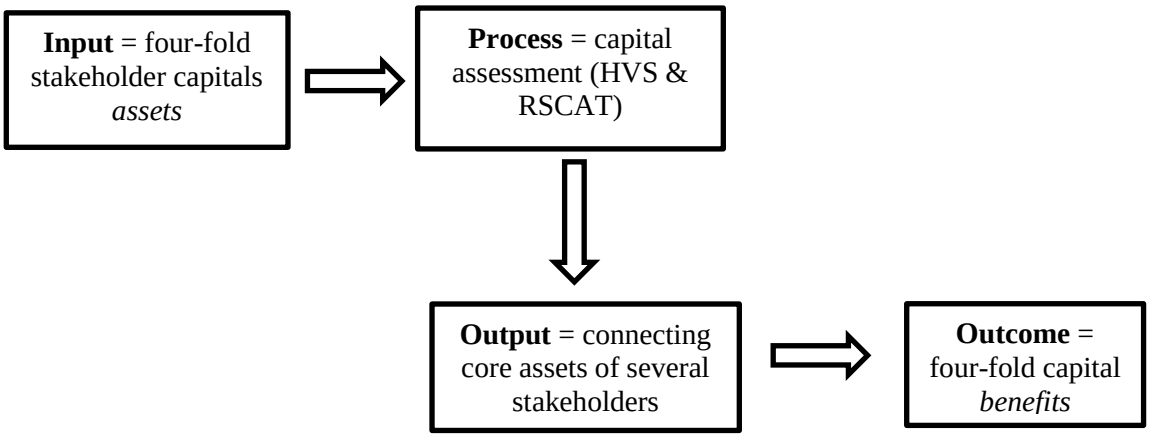
**Combines Core Concepts 3.8.1 – 3.8.7. Figure 3.3 (supply) includes drivers, opportunities, barriers & failure factors. Figure 3.4 (demand) includes drivers, opportunities, critical success & failure factors. Hybrid Value System (HVS) – an ecosystem that relies on connecting the core assets of several stakeholders (Section 2.2.4 & 3.8.8.1).*

3.8.8.3 Conceptual Framework as process model – input, output, outcome

To simplify the conceptual framework, and capture it as a process model for assessment, the following diagram (Figure 3.6) details how the four-fold capitals will be addressed as *inputs* (e.g. stakeholder assets/resources). The process of assessment (e.g. HVS & social capital assessment) and the *output* of connecting the core assets of several stakeholders. The *outcome* will determine if a multi-capital, multi-stakeholder assessment achieved the four-fold capital benefits, or if further interventions are required to help bridge the digital divide.

Figure 3.6 Conceptual framework as process model

(To measure input, process, output & outcomes)



3.8.8.4 Why does this research matter & what means are proposed to study it?

In summary, local actors, capitals, ecosystems, networks and stakeholder collaboration are required at the local community-level. Creative, multi-stakeholder collaboration, new business models, partnerships and open innovation are required (Halseth et al., 2019; The Boston Consulting Group, 2016). The IM literature requires 21st century organisations to engage in open innovation (OI), co-creation and multi-stakeholder practices (Section 3.7). The conceptual framework seeks to capture these concepts and apply them within a multi-capital-multi-stakeholder hybrid-value NED ecosystem (Figure 3.5). The most relevant and complementary process to consider how to get an NGA (product) to a final few (market) is the mutual business HVS approach introduced by Roche & Jakub (2017) (Section 3.8.8.1, Table 3.13). The conceptual framework encapsulates the local rural community ecosystem with the exogenous supply and endogenous demand complexities, challenges and opportunities (Figures

3.3 – 3.5). The mutual business model values the four-fold capitals, as both financial and non-financial assets, and seeks to assuage competing frustrations within the stakeholder ecosystem (Section 1.1, 2.2.4, 3.6.5, 3.6.6 & 3.7.3). The mutual business HVS is the primary instrument selected to address NED (Section 3.8.8.1). Thus, a qualitative (e.g. interview approach) will be required to identify individual stakeholders' capital contributions and pain points within both ecosystems to answer the RQs.

3.9 Conclusion of Literature Review

In conclusion, the research gaps identified require more multi-method studies (Section 3.2.3) at the local level incorporating both exogenous supply and endogenous demand stakeholders (Section 3.4.1 & 3.5.1).

The community-led initiatives (OBJ1A) revealed critical success and failure factors that have been included in the conceptual framework (Figure 3.4). Supply-side studies (OBJ1B) are currently in a state of flux given the rapidly changing UK Government rural gigabit connectivity plans (Section 3.5.2). However, the current supply-side challenges reside in the need for more alternative business models and creative partnerships to aid local community engagement (Halseth et al., 2019; INCA, 2012). Demand-side studies (OBJ1C) included diffusion theories, but rural community and user context is required to consolidate the factors supporting adoption (Section 3.5.2).

The drivers and opportunities for Industry 4.0 and NGA (OBJ2A) can be summarised as development and growth in human capital (e.g. education), social capital (e.g. migration), environmental capital (e.g. teleworking) and financial capital (e.g. Internet of Things (IoT), job creation). For example, rural communities can benefit from farm diversification and RFID tags (Section 3.6.1).

The drivers and opportunities for supply (OBJ2B) includes new business models, barrier busting taskforce and funding support at the community level (3.6.2.1.1). Drivers and opportunities for demand include local authority engagement to promote take-up and benefit from claw-back clause for re-investment (Section 3.6.2.2.1).

The barriers (OBJ2C) can be summarized by the endemic challenges related to rural broadband that includes environmental challenges (e.g. geographical distances),

financial challenges (e.g. costs & returns of investment), human challenges (e.g. lack of education & skills to stimulate demand using relevance & usefulness of NGA products & services) and social challenges (e.g., low populations) (Section 3.6.3.1). These barriers range from macro (e.g. government & commercial challenges) to micro (e.g. community & individual challenges).

The critical success factors (CSFs) that contribute to the implementation and take-up of NGA in final few and hard to reach rural communities (OBJ2D) has been identified as local digital champions (LDCs), the value of human capital (e.g. IT skills), social capital and trust (Section 3.6.4). The theoretical underpinnings for human & social capital as CSFs were explained in (Section 3.6.5 & 3.6.6).

The innovation analysis (OBJ3) revealed the various options available to communities and companies when operating in a 21st-century digital ecosystem, including multi-stakeholder engagement (Section 3.7).

The theoretical constructs identified in community-led rural broadband underpin this research by combining neo-endogenous (NED) approaches (e.g. linking internal local actors with external networks), the value of human, social and place-based capitals (Section 3.2.4). Intermarriage between the social sciences (e.g. management, economics, geography & sociology) is required to maintain academic rigour (Shafique, 2013; Terluin, 2003) (Section 3.2.4).

Schumpeter (1959), Castells (2010), Chesbrough (2017), Tidd & Bessant (2015; 2009) argue the inevitability of innovation's creative destruction and the impact on entrepreneurs and microbusinesses (MBs) (Section 3.3.4 & 3.3.5). This, coupled with the digitally-networked-work-from-anywhere phenomenon and an open innovation (OI) collaboration of multiple stakeholders, are required to facilitate the incoming knowledge flow of the 21st century (Section 3.7.1 – 3.7.4). The goal is to capture the financial and non-financial appropriability rewards (Teece, 2006), such as the non-pecuniary value of gatekeepers, trust and the human & social capital required in order to sustain local communities (B4RN, 2011; Gerli & Whalley, 2018; Von Hippel, 2005) (Section 3.5.1.2 & 3.7.1).

The urban-rural digital divide is a persisting problem area (Section 3.3.6), but the rural broadband literature suggests that local community engagement in a multi-

stakeholder analysis can resolve the supply and demand opportunities and challenges (Philip et al., 2017; Salemink et al., 2017b). The summarized gaps in the current research are listed in the following (Table 3.14).

Table 3.14 Summary of Literature Review - gaps for future research

Gaps for future research	***Literature***
Academic field: More multi-method studies are required	(Section 3.2.4)
Academic field: Linking the social sciences (e.g. economics, sociology & management) to maintain cross and multi-disciplinary research	(Section 3.2.4 & 3.7)
Rural broadband literature: Localised community-level approach – more local consultation to uncover unique qualifications and embedded capitals	(Section 3.5 & 3.6)
Rural broadband literature: Value of human capital – critical success factor (CSF)	(Section 3.5 & 3.6)
Rural broadband literature: Value of social capital & trust – critical success factor (CSF)	(Section 3.5 & 3.6)
Rural broadband and IM literature: New business models – customised approach, creative partnerships & to include multiple collaborations, communities & entire ecosystems.	(Section 3.6.2 & 3.7.3)
Innovation management (IM) literature: Appropriability challenge - financial & non-financial value	(Section 3.7)
IM literature: New metrics & processes required.	(Section 3.7)
IM literature: Multi-stakeholder & ICT ecosystem engagement	(Section 3.5 & 3.7)

3.9.1 Revision of research questions (RQs)

The proposed RQs are:

RQ1. What capital resources, financial and non-financial, are required to support infrastructure for NGA to be viable for rural communities and microbusinesses (MBs) to experience the four-fold capital benefits?

RQ2. How can multiple stakeholders in both supply and demand ecosystems mutually learn and cooperate to resolve this complex rural digital divide challenge?

RQ3. What new and innovative approaches can be utilized to manage and measure this process?

The evidence provided in the literature confirms that more is required to support infrastructure to enable NGA to be viable for rural communities and MBs to experience four-fold capital benefits. Supply of NGA alone will not give rural communities and MBs the awareness and skills required to promote demand and take-up or exploitation of this new wave of innovation. The empirical evidence shows that multi-capital and multi-stakeholder engagement at the localized level is required. Overall, the RQs remain valid, with the exception of RQ2 which was updated to capture the mutual learning and cooperative interplay of stakeholders as a key for successful rural broadband initiatives (Section 3.5.1.1).

The research aim identified in (Section 1.2) is to enable rural communities and MBs to access and exploit NGA services, in preparation for Industry 4.0. The research objectives (OBJ) addressed in the literature review will inform the methodology (Chapter Four) and summarised in the following (Table 3.15).

Table 3.15 Summary of research OBJs & methods used to inform methodology

Research Objectives	***Methods***
OBJ1A. To evaluate community-led initiatives in providing advanced broadband in the final few & hard to reach rural communities.	Literature review (Section 3.5.1) Core concepts & gaps identified to develop conceptual framework & instruct methodology to answer RQs.
OBJ1B. To evaluate the supply in providing advanced broadband in the final few & hard to reach rural communities.	Literature review (Section 3.5.2 – 3.5.4) Core concepts & gaps identified to develop conceptual framework & instruct methodology to answer RQs.
OBJ1C. To evaluate the demand in providing advanced broadband in the final few & hard to reach rural communities.	Literature review (Section 3.5.2 – 3.5.4) Core concepts & gaps identified to develop conceptual framework & instruct methodology to answer RQs.
OBJ2A. To identify the drivers & opportunities related to Industry 4.0 & NGA.	Literature review (Section 3.6.1) Drivers & opportunities identified in relation to Industry 4.0 that can affect conceptual framework.
OBJ2B. To analyse the drivers & opportunities related to the implementation (supply) & take-up (demand) of NGA in final few & hard to reach rural communities.	Literature review (Section 3.6.2) Drivers & opportunities identified in supply & demand that can affect conceptual framework.
OBJ2C. To analyse the barriers to the implementation & take-up of NGA in final few & hard to reach rural communities.	Literature review (Section 3.6.3) Barriers identified in supply & demand that can affect conceptual framework.
OBJ2D. To analyse the critical success factors (CSFs) that contribute to the implementation & take-up of NGA in final few & hard to reach rural communities.	Literature review (Section 3.6.4) CSFs & definitions used to inform *a priori* codebook for semi-structured interviews.
OBJ3. To identify new & innovative alternatives in ICT supply & demand resolution that can be applied to bridge the digital divide gap in final few & hard to reach rural communities.	Literature review (Section 3.7) Identification of the Hybrid Value System (HVS) to engage exogenous & endogenous stakeholders. Adapted World Bank Social Capital Tool (SCAT) to evaluate social fertility for investment.

To conclude, a multi-method qualitative research design will be required to investigate the exogenous supply and endogenous demand stakeholders' individual challenges and capital resource contributions according to the Hybrid Value System (HVS) and World Bank Social Capital Assessment tools. Thus, the research design and methodology will be explained in the following (Chapter Four).

Chapter Four: Research Design & Methodology

4.1 Introduction & Chapter Overview

This chapter discusses the research philosophy and methodologies selected to answer the research aim, objectives (OBJs) and research questions (RQs) described in (Section 1.2). As discussed in (Section 3.8 & 3.9) and shown in (Table 3.14 & 3.15) multiple data collection tools must be utilised to answer the different RQs. The remainder of this chapter focuses on the qualitative methods identified to investigate the RQs and will be summarised in (Section 4.10.5, Table 4.5).

This chapter has two sections; the first introduces the philosophical and theoretical viewpoints underpinning the study, concluding with an overall summary (Section 4.6). The second details the practical methods, including the case study protocol and data collection and analysis tools, required to operationalise and validate the research design (Sections 4.7 – 4.12). A conclusion of the research methodology is summarised in (Section 4.13).

4.2 Research philosophy

Prior to explaining the methodological choices selected to address the problem area, the epistemological (or what constitutes knowledge) and the ontological (or lenses from which one views reality) positioning of the phenomenon needs to be stated (Jankowicz, 2000; Ravitch & Riggan, 2016). Thus, this section aims to capture some of the lenses from which this research and data collection (or evidence) can be understood.

As previously explained (Section 3.2.4), the academic field relating to rural studies and how to resolve the digital divide has cultural and political biases depending on the onto-epistemological viewpoint of the researcher or political culture from which policies are enacted (Section 3.2.4). As described throughout (Section 3.3, 3.5 & 3.6) these differing viewpoints colour the lenses from which stakeholders view the problem area and solutions therein, providing an opportunity for a philosophical convergence that the mutual business HVS approach represents, drawing the concerns of various viewpoints (e.g. environmental, socialism & capitalism) into a middle ground for collective action to bridge the digital divide.

While the goal of this thesis is to resolve the digital divide challenges by getting an NGA (product) to the final few (market), the complexities of the supply and demand ecosystems and the varying onto-epistemological viewpoints of both researchers and stakeholders must be understood.

4.2.1 Complex ecosystems – Stakeholder onto-epistemological lenses

The rural broadband phenomenon is influenced by multiple stakeholder realities (Section 2.1). Thus, the ontological position of what constitutes "reality" to stakeholders in a complex ecosystem can be objective (positivist) if viewed holistically as a problem area (e.g. digital divide challenge), but subjective (interpretivist) to individual stakeholder viewpoints. For example, an Openreach interviewee will be influenced by the reality of managing stakeholder value on which their future employment entails. A governmental interviewee will be influenced by political partisanship both externally (objectively) and internally (subjectively). Rural residents and MBs will view reality from their individual experiences of having NGA or not, and the political and cultural experiences in trying to resolve the problem (as stated above). Hence, the ontological reality of a complex ecosystem is subjective to the individual stakeholders and the objective reality of the various political and cultural experiences therein (Bansal, Smith, & Vaara, 2018; Cassell, Cunliffe, & Grandy, 2018).

Conversely, the accumulation and transfer of knowledge (epistemological viewpoints) within and without the ecosystem are equally objective to the problem area, but subjective to the individual stakeholder. For example, an Openreach interviewee understanding of the problem area and the knowledge required to resolve the problem is different to how a rural resident understands the problem and vice versa. Henceforth, knowledge sources within the complex ecosystem are formed by both interpretivist (subjective) and positivist (objective) influences (Collis & Hussey, 2014; Huberman & Miles, 2002). The objective-subjective continuum will be explained further in (Section 4.3.2).

The variations of human capital (e.g. individuals unique tangible & intangible/tacit skills & knowledge), and the social capital required (e.g. how the tangible & intangible/tacit knowledge is transferred) are individually and collectively subjective. Thus, the onto-epistemological reality of rural broadband is a complex and evolving

phenomenon with a multitude of experiences, influences and realities (Jankowicz, 2000).

4.2.2 New paradigmatic thinking

A further consideration is what assumptions underlie this inquiry. The literature identified various capitals as assets and benefits (Section 3.5 & 3.6). In business management research it is suggested that change is required to re-evaluate "capital" and what constitutes "value" (Section 3.7.3). Thus, new paradigms are required (Roche & Jakub, 2017; Saunders et al., 2016). Ning Su explains a paradigm *"can be viewed as a network of basic, metaphysical assumptions underlying an area of academic inquiry"* (Cassell et al., 2018, p. 17). The term *paradigm shift* is attributed to Thomas Kuhn (1962) who explains the termination of one set of normative science techniques into a new set of techniques required to understand the phenomena. Evaluating financial and non-financial capital as a tangible value-add in resolving rural supply and demand challenges is a paradigmatic shift away from previous, solely economic norms (Section 3.7).

In summary, there is a network of complex assumptions underlying this inquiry. The following section on research design (Section 4.3) will detail these positions further as it explains and underpins the research methodology (Section 4.5).

4.3 Research design

The research onion was developed to guide business management researchers in understanding the different world views and approaches individuals take to study a phenomenon (Saunders et al., 2016). The stages of the research onion review the various philosophies (e.g. interpretivist & positivist), approaches to research (e.g. abduction, deduction or induction), methodological selection (e.g. qualitative), strategy selection (e.g. case study), time required to conduct research (e.g. cross-sectional or longitudinal) and the data collection and analysis techniques required for the study (p. 124). The following sections will utilise these stages to explain the overarching philosophy and overall research design selected for this thesis (Section 4.6).

4.3.1 Ontological, epistemological & axiological viewpoints

Underpinning research are some fundamental assumptions in what constitutes good or accurate knowledge and the conceptual arguments about what it means to be or to exist (Hatch & Cunliffe, 2006). If the "tip of the iceberg" is what is "seen" in research, typically viewed as the choice of methods (e.g. interviews or surveys), then the ontological (view of reality), epistemological (knowledge gain) and axiological (ethical) positions are what lies beneath the surface which shapes the decision-making process (James, 2015, January 29). These philosophical viewpoints bias, drive, inform and underpin decisions on how the research is conducted and influenced (Jankowicz, 2000; Magee & Berlin, 1976).

King and Brooks (2018) suggest researchers must state their onto-epistemological view, so the audience can understand the approach and interpretation of the data. In relation to generic qualitative thematic analysis, the authors recommend four broad categories to state philosophical positions (p. 4). A summary is provided in (Table 4.1).

Table 4.1 Philosophical positions when using generic thematic analysis (King and Brookes (2018, p. 5)

Philosophical position	In relation to qualitative generic thematic analysis approach
Neo-positivist: Ontology (Realist) Epistemology (Realist)	Seeks to build or test theory, minimising impact of researcher subjectivity, use of independent coders to verify accuracy of themes, may use strong, theory-linked *a priori* themes.
Limited realist: Ontology (Realist) Epistemology (Constructionist/Relativist)	Seeks to develop an account that is credible and potentially transferable, while recognising conclusions will always be tentative. Often uses *a priori* themes informed by theory or evaluation criteria. Quality checks to stimulate critical thinking, specific to needs of particular study. Reflexivity in analysis is important, to go beyond researcher subjectivity.
Contextualist: Ontology (Relativist or Indeterminate) Epistemology (Constructivist/Relativist)	Seeks to understand participants meaning making within the specific research context. Focus on induction and emergent themes; highly tentative use of prior themes (if at all). Reflexivity: researcher subjectivity integral to whole process.

Radical Constructionist: Ontology (Relativist) Epistemology (Strongly Relativist)	Seeks to critically examine how the phenomena of organisational life are constructed, including how organisational research itself constructs knowledge. Scepticism about any quality criteria in analysis. Focus on themes as aspects of discursive construction rather than of direct experience.

Lincoln and Guba (1994) explain a constructivism paradigm ontology (e.g. local, specific & relative constructed realities) and epistemology (e.g. creative, subjective & transactional findings) (p.168) which reflect this study's inquiry into knowledge gain. This means the local stakeholders' and researcher's view of reality is what is relevant to them and specifically constructed to their viewpoints. The knowledge accumulation is creative, subjective and transactional to stakeholders and the researcher's experience.

Moreover, Lincoln and Guba (1994) explain the constructivist attitude towards the nature of knowledge (e.g. individual reconstructions coalescing around consensus) and knowledge accumulation (e.g. more informed & sophisticated reconstructions or vicarious experience) (p. 170) which again reflects this study's inquiry. The aim of the Hybrid Value System (HVS) is to understand individual stakeholder viewpoints, seeking consensus and vicarious experiences into problem area resolution. Thus, the constructivist onto-epistemological viewpoints capture the data collection and analysis strategy of this inquiry.

Furthermore, although the natural proclivity of this researcher is pragmatism (summarised in Section 4.3.2), in relation to handling thematic data analysis, a "limited realist" approach with a "constructionist epistemology" is declared (Table 4.1). An "indeterminate constructivist contextualist" approach could be considered, but the aim is not participant meaning making, although a specific research context to consider induction of emergent and theoretical themes is relevant. The primary aim of this thesis is to develop a credible and potentially transferrable approach using *a priori* themes. Thus, a limited realist is more appropriate to allow construction of this aim. This researcher agrees with Miles & Huberman (1994, p. 5) definition of a realist, because not all knowledge is tangible. The authors state a "transcendental realism" approach which is anchored in realism but recognises "intangibles" such as trust (e.g. trust is "real" but cannot be seen or touched). Trust is a critical success factor (CSF) identified

in this thesis and recognised as a primary concept for economic and social interactions (Section 3.6.4). Hence, this researcher's approach to qualitative thematic analysis will be a limited realist with constructionist epistemology to answer the RQs (e.g. pragmatic approach). A more detailed explanation of business research paradigms is discussed in following section.

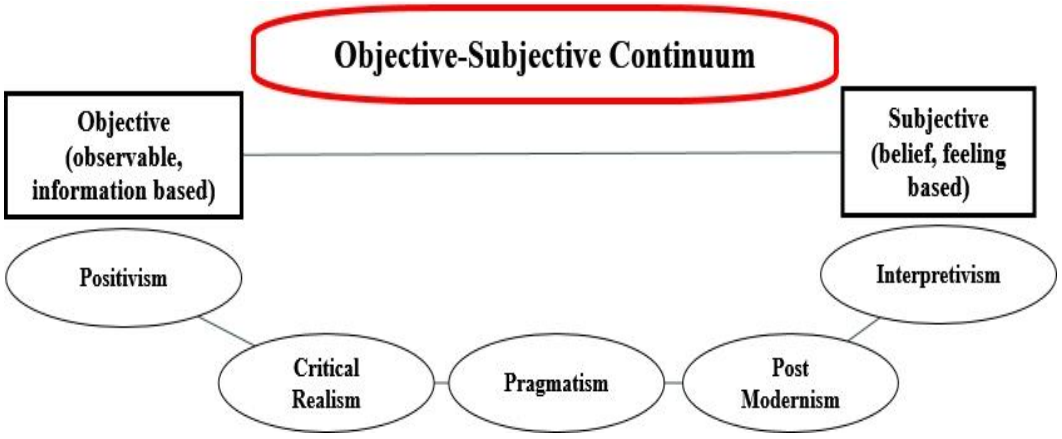
4.3.2 Modern business management philosophical approaches

In attempting to understand the common philosophical approaches utilised in the management literature, the work of Saunders et al. (2016), Bryman & Bell (2015), Creswell (2014), Collis & Hussey (2014), and Hatch & Cunliffe (2006) were investigated to determine the most appropriate approach for this study.

Saunders et al. (2016) suggests there are five main philosophies shaping business management research. Business management research evolved and adopted philosophies from more established fields such as natural sciences, arts and humanities and social sciences (e.g. anthropology, psychology & sociology). There are many research philosophies used to study other fields, but the five philosophies reviewed in relation to business management are positivism, interpretivism, critical realism, pragmatism and postmodernism (p. 151).

Research philosophies can be identified by their position on the objective (based on observation information) and subjective (based on beliefs or feelings) continuum (Hatch & Cunliffe, 2006). To explain the extremes of the objective and subjective spectrum, the two primary opposing philosophical positions are positivism (objective) and interpretivism (subjective) and summarised in (Figure 4.1).

Figure 4.1 Objective-subjective continuum



Philosophical world views range across the objective and subjective viewpoints (Saunders et al., 2016). Research philosophies, such as critical realism and pragmatism, aim to combine these opposing views, while postmodernism aims to deconstruct the major assumptions of Western philosophies with a radically individual and subjective viewpoint (Bryman & Bell, 2015; Hatch & Cunliffe, 2006). The evolution of philosophical thought moves from late 18th century (e.g. positivism) to more contemporary approaches (e.g. postmodernism).

Positivism is said to have originated with the French philosopher August Comte in the late 18th century (Collis & Hussey, 2014), although it can be argued further back in history (Burns, 2000). *Logical positivism* originated with a group of philosophers, namely Moritz Schlick, Otto Neurath, and Rudolph Carnap, from the University of Vienna known as the Vienna Circle (Magee & Ayer, 1978; Saunders et al., 2016). The positivist's view themselves as objective (e.g. external to social actors or human interpretation & bias) and adopted a natural science approach to knowledge (Saunders et al., 2016). Quantitative methods (e.g. experiments or surveys) are associated with positivist research because these are the epistemological tools of the natural sciences (Burns, 2000; Collis & Hussey, 2014).

Interpretivism (or *anti-positivism*) was a reaction to the natural science or "objective only" approach to social science or human action research (Hatch & Cunliffe, 2006). Interpretivists argue people make judgements, create meaning, are more complex than the physical world and cannot be studied in the same manner as physical matter (Burns, 2000; Saunders et al., 2016). Interpretivism originated with several philosophers, including Max Weber and Wilhelm Dilthey from Germany (Bryman & Bell, 2015; Saunders et al., 2016). Saunders et al. (2016) cite Crotty's 1998 explanation and summarises that "interpretivism" emerged in early and mid-twentieth through European philosophers and is formed of several strands; most notably hermeneutics (to interpret or translate), phenomenology ("that which appears") and symbolic interactionism (p. 140). Symbolic interactionism focuses on the individual and the symbols used by the individual to communicate meaning (Hatch & Cunliffe, 2006). Interpretivism (or anti-positivism) is subjective, qualitative and considered to be at the opposite end of the spectrum to positivism/objectivism (Bryman & Bell, 2015).

Pragmatism as a research philosophy aims to reconcile the extremes of the objective versus subjective viewpoints (Bryman & Bell, 2015). The founder of pragmatism is the American Charles Sanders Peirce who was concerned with how to make ideas clear (Magee & Morgenbesser, 1987). In addition, William James and John Dewey were contemporaries of Peirce (Magee & Morgenbesser, 1987). All three men were influential by stating knowledge should have a practical output to be of value (James, 1907). Saunders et al. (2016) define pragmatism as *"concepts are only relevant where they support action; it considers research with a problem and aims to contribute practical solutions that inform future practices"* (p. 724).

Critical Realism originated with the British philosopher Roy Bhaskar in mid-20th century and is another attempt to reconcile the objective and subjective continuum (Saunders et al., 2016). Bhaskar (2014) states that critical realism is a philosophy concerned with ontology because you could not reduce statements about the world into statements about epistemology only. The author (2014) argued against ontological mainstream philosophy which pictured the world as unchanging, undifferentiated and unstructured versus a view of reality as changing, differentiated and structured. Critical realism central tenets state that truth is "out there" and is deep, emergent, generative and stratified. The focus is on explanation or "why" questions or why do things happen the way they do? Realities are a complex, open-system and approach to research is an eclectic methodology (Clark, 2015). McGrath (2016) expounds that Bhaskar understood the world is more complex and not solely objective but subjective. More specifically, the "ontology determines the epistemology" (Guba & Lincoln, 1994). The way things are, affect the way in which we know them, and the extent which they can be known. Bhaskar argued that one method could not be expected to know everything (McGrath, 2016). Saunders et al. (2016) define critical realism as a "*philosophical stance that what we experience are some form of the manifestations of things in the real world, rather than the actual things"* (pg. 714). The authors (2016) use the example of watching a sporting event on TV. The advertising on the pitch looks like a billboard, but it is not a billboard. It only appears as such, but it is, in fact, an optical illusion; cleverly painted onto the pitch to make it appear as if it is "real" (p. 139). Bhaskar would argue what appears to be objective, is, in fact, subjective, and "critical realism" analysis is required to explain the phenomenon.

Postmodernism originated with French philosophers, such as Jean-Francois Lyotard, Jacques Derrida and Michel Foucault (Hatch & Cunliffe, 2006). Lyotard is known for his objection to what he defines as the "Grand Narratives" of the Enlightenment; Foucault for "Discourse", and Derrida for "Deconstruction" of language (Hatch & Cunliffe, 2006). Some schools of thought place the postmodern era after World War II or at the end of the 20th century marking the end of the Enlightenment (Hatch & Cunliffe, 2006). There are arguments about postmodernism not being a philosophical debate but more literary discourse (Chomsky, 2011). Saunders et al. (2016) define postmodernism as *"emphasizing the role of language and power relations that seek to question accepted ways of thinking and give voice to alternative marginalized views"* (p. 724). Postmodernist research is typically associated with qualitative research, because of the highly subjective and reflexive viewpoints (Hatch & Cunliffe, 2006; Saunders et al., 2016).

The Role of the Researcher

Saunders et al. (2016) introduce a self-assessment questionnaire entitled HARP (Heightening Your Awareness of Your Research Philosophy) (p. 153) to determine researcher preferences towards one philosophical stance over another. The results for this researcher revealed 1) pragmatism as the highest score; 2) critical realism and 3) interpretivism. Negative scores are postmodernism and positivism. This questionnaire reveals the personal preferences of philosophical inquiry and the bias therein. Given pragmatism is a natural proclivity for this researcher it will be the philosophical worldview and the underpinning approach for this thesis. Cassell et al. (2018) state the role of the researcher in the research process *"lies a recognition that we are part of the organisational world that we study and therefore this will impact the methods, processes and outcomes of our research"* (p. 8). Hence, researcher reflection/reflexivity is encouraged throughout this process.

In summary, the philosophical underpinning of this research is pragmatism, in part because of the researcher's own world view, but also because of the practical aim of this research to provide an NGA (product) to a final few (market). As a result of the analysis, objective/positivist approaches were found to be unsuitable given the reliance on stakeholder attitudes and viewpoints in answering the RQs (Section 4.2). Given the potential for bias in this approach, researcher reflection is required to understand and

consider without prejudice all of the various stakeholder viewpoints within the complex ecosystem under investigation.

4.3.3 Reflection & reflexivity

Reflection and reflexivity are sometimes used synonymously, but the relevance and understanding of reflexive practice can be ambiguous and complex (Barrett, Kajamaa, & Johnston, 2020; Corlett & Mavin, 2018; Johnson & Duberley, 2003). The challenge of defining reflection versus reflexivity is that the word reflection is often used to describe reflexivity and reflexive processes which is evidenced throughout the extant literature (Barrett et al., 2020; Corlett & Mavin, 2018; Johnson & Duberley, 2003; Lynch, 2000).

For example, recent studies such as Corlett & Marvin (2018) state reflexivity is considered integral to qualitative research and define it as *"reflecting upon the ways in which we carry out our empirical research projects and explaining to the audience how we move through research manufacturing process to certain conclusions"* (p. 2). Barrett et al. (2020) describe reflexivity as a *"combination of reflection, and its outcome (e.g. a defined action that comes about as a result of that reflection) and recursively, where we consider those outcomes in context"* (p. 10). The use of the term reflection when differentiating it from reflexivity can add to the confusion but clarification is required.

In recent business management studies on reflexivity, Corlett & Marvin (2018) explain how the development of reflective versus reflexivity practices while conducting research evolved from the context of discussing shifts from modern to postmodern thinking. The authors cite Pillow's 2003 example of a researcher coming from a modernist understanding of self as *"singular & knowable"* as opposed to a postmodern understanding of "*self as multiple & unknowable*" will position reflexivity purposes and practices differently (p. 3). More specifically, the authors cite Hibbert et al. in 2010 who go further and understand reflexivity to be related to reflection, but it is qualitatively different and state, for them, *"whilst reflection might enable researchers to observe research practice, as it might be reflected back to them from a mirror image, reflexivity involves 'exposing or questioning our ways of doing'"* (Corlett & Mavin, 2018, p. 2). The statement "for them" is significant because there are multiple subjective interpretations of reflexivity and how it can be applied to

different research fields (Braun & Clarke, 2019; Breuer, Mruck, & Roth, 2002, September; Lynch, 2000).

Barrett, Kajamaa & Johnston (2020) define reflection as a *"goal-orientated action with the aim of improving practice, whilst reflexivity is a continual process of engaging with and articulating the place of the researcher and the context of the research"* (p. 9). The authors provide a simplified table to define reflection versus reflexivity (Table 4.2).

Table 4.2 Reflection versus reflexivity

(Barrett et al., 2020, p. 10)

Reflection	Reflexivity
Goal oriented	Continuous activity
Collective action	Informed by reflection
Aim: to question, evaluate & re-think practice	Aim: to facilitate consideration of our understanding of culture, social realities & position

The primary argument over reflection versus reflexivity is focused on the ontological and epistemological debate on what constitutes "knowledge claims" (Breuer et al., 2002, September). Pierre Bourdieu is recognised with developing the concept of reflexivity in social science research (Emirbayer & Desmond, 2012; Maton, 2003) although it can be traced back further.

Maton (2003) discusses Bourdieu's introduction of "epistemic reflexivity" which comprises of not simply focusing on the relationship between researcher and object, but between the researcher, object and the researcher's relationship with the object. This epistemic reflexivity or introduction of "knowledge reflexivity" resulted in an "objectification of objectification" and what Bourdieu argues is the epistemological basis for scientific knowledge (p. 57). Maton (2003) argues for more development of Bourdieu's "innovation" of "objectifying objectification" in reflexive research but acknowledges where does this type of reflexive analysis end? Eventually, without specific acknowledgement as to why reflexive questioning is required, the argument comes full circle and becomes narcissistic, individualistic and sociologically reflexive as opposed to Bourdieu's ideal of reflexivity as epistemological, collective and objective (p. 58).

In business management research, Johnson & Duberley (2003) try to summarise the ontological and epistemological argument by introducing the differences of reflexivity thinking across the objective and subjective continuum and the arguments between modernist (e.g. foundationalism) and postmodern (e.g. relativism) philosophical assumptions as to what constitutes knowledge (p. 1282). The authors provide an analysis of epistemological objectivism with ontological realism and epistemological subjectivism and ontological subjectivism. The authors (2003) summarise their analysis through three separate considerations to reflexive practice in business management research. On the objective side of the scale is *methodological reflexivity* (or thesis) which focuses on a realist ontology and tries to find neutral observational language as an outsider evaluating the research object. The second practise is *epistemic reflexivity* (or synthesis), described above, whereby the ontology may be realism but the epistemology is subjective. Finally, *deconstruction or hyper-reflexivity* (or antithesis) argues against neutral observational language by stating knowledge and truth are linguistic entities constantly open to argument or revision (p. 1285).

Moreover, Lynch (2000) states some research programmes treat reflexivity as a methodological basis for enhancing objectivity whereas others treat it as *"a weapon for undermining objectivism"* (p. 26). Lynch (2000) argues against reflexivity as an academic virtue and states *"reflexivity or "being" reflexive, is often claimed as a methodological virtue and source of "superior insight" but it can be difficult to establish what is claimed"* (p. 26). Lynch lists some examples of reflexive practices from psychology, systems theory and more radical conceptions in cultural and social theory (p. 27). For example, the author provides a preliminary reflexivity inventory and lists mechanical (or feedback loops), substantive (or entire global social system analysis), methodological (discussed above), meta-theoretical (attitude or perspective), interpretive and ethnomethodological reflexive practices (p. 27). These reflexivity practices involves some sort of recursive "turning back". Lynch questions what that turning, how it turns and with what implications from category to category and from one case to another within a given category (p. 34). Hence, these inquiries can be inexhaustive if not specified as to why reflexivity is required to enhance the validity of the study.

To determine if reflection or reflexivity was relevant to this research, the reflexivity questions posed by Corlett & Marvin (2018) for business management research was trialled (see Appendix O). This researcher analysed if reflexivity was a relevant or valuable tool for this research. As shown in Appendix O, if this research considered gender analysis in decision making for rural broadband or if the focus was on political party decision making or analysis (or power relations) then reflexivity may have contributed to this type of inquiry. However, as explained in Appendix O, the aim and focus of this research is how to get a product to market. Thus, a reflective practical analysis was applied, and researcher biases and onto-epistemological viewpoints have been declared (Section 4.2 – 4.3).

In summary, although reflexivity has its place within certain fields of academic inquiry, this researcher holds a modernist view of research (as opposed to postmodern analysis of gender/race/power relations) and thus reflects upon how a pragmatic reflective and methodological reflexive approach will answer the research aim and questions. Ultimately, it is this researcher's opinion, that all research is subjective and can be argued into perpetuity, but it will be up to the readers to discern if this research has contributed a meaningful and relevant contribution to knowledge in relation to the topic of rural broadband and how to bridge the digital divide in Wales.

4.3.4 Purpose & theory development

As explained in (Section 1.1) the rural digital divide is a complex NED ecosystem, and a multi-capital and multi-stakeholder approach is required at the local community level. The mutual business HVS approach (Section 3.7.3) is a new "green field" of management science. Hence, the goal of this research is to develop an understanding of what capital resources (both financial & non-financial) are available and how that capital can be valued for a more holistic approach to business (Section 3.8.8).

To develop this understanding, the research requires an exploratory approach to investigate alternatives to supply and demand resolution (Baxter & Jack, 2008; Yin, 1994). In addition, a descriptive element is required to enhance the comprehension of how to value non-financial capital assets (Collis & Hussey, 2014). Furthermore, an explanatory approach will be applied to the findings in order to understand "how & why" the capitals can be utilised and employed (Runeson & Höst, 2008; Saunders et al., 2016).

This combined approach may include more than one purpose; this is often the case in multi-method studies where the use of interviews to facilitate data collection can have descriptive, exploratory, explanatory and evaluative inferences (Saunders et al., 2016, p. 177). A multi-method approach is suitable for this research as suggested by the multiple factors in the conceptual framework (Section 3.9). Therefore, a combined approach to describe, explore and explain individual stakeholder viewpoints to answer the RQs is appropriate.

4.3.4.1 Theory development – Hybrid abductive approach

The approach to theory development selected for this study was to first identify a conceptual framework and *a priori* themes from the literature. This is exploratory in nature and inductive (Bryman & Bell, 2015) in that the work and data of others is used to develop theory.

The primary data collection and analysis presents an opportunity to test the identified themes and further develop the theory as a result. This hybrid approach to theory development, called "abduction", is appropriate to this study in that the state of knowledge of the theory is too far advanced to be described as purely inductive, and not yet at a stage to develop a hypothesis suitable for testing such as would be used in deductive theory development. The abductive approach to theory development is a combination of inductive and deductive (Cassell et al., 2018). Abduction moves from data to theories, by collecting data to identify themes, explain patterns, and to generate new or modify existing theories (e.g. inductive & qualitative) which are in turn tested through additional data collection (e.g. deductive & quantitative) (Saunders et al., 2016). Although abductive is often related to mixed methods because it combines quantitative and qualitative approaches (Creswell, 2015), it can also be considered a hybrid approach (e.g. *a priori* themes from theory, tested through qualitative means). Hence, a hybrid abductive approach is relevant for this research.

In conclusion, the methodological approach selected for this research is as follows. A pragmatic philosophical approach (James, 1907; Magee & Morgenbesser, 1987) will underpin this research, because of the practical output required to answer the RQs and the researcher's natural proclivity towards the philosophy. The nature of the mutual business HVS approach utilizes qualitative and multi-method assessments (Roche & Jakub, 2017). A positivist (quantitative only) approach cannot be adopted

for this reason (Magee & Ayer, 1978). A postmodernist view (predominantly qualitative & subjective) is equally not adopted, because the deconstruction of language or the dependence upon gender, power relationships, race or any other minority view, are not considered relevant to answer the RQs (Hatch & Cunliffe, 2006). Critical realism could be considered for this research, but an explanation of the phenomena is not the primary goal (Bhaskar, 1978; McGrath, 2016). Interviewing relevant NED stakeholders involved in the rural community and seeking to identify non-financial capital resources requires an initial exploratory approach but will contain a combined approach to describe and explain various aspects of the phenomena. A partial interpretivist worldview (qualitative only) can be adopted, but this is not solely a subjective endeavour. The research aims to provide practical output for management practitioners and stakeholders. Thus, a pragmatic, abductive, exploratory and multi-methods approach will be utilised to answer the RQs.

4.4 Research domain

This research aims to benefit rural communities, microbusinesses (MBs), commercial ICT suppliers and local governments by proxy. The focus of the study, or the primary actor, is a final few and hard to reach rural community in Pembrokeshire, South Wales (Section 2.1.4). Advanced broadband enables the four-fold capital benefits for rural communities and MBs growth and development, which in turn benefits commercial ICT suppliers and the local government (Carayannis & Campbell, 2013) (Section 3.7.4).

Nonetheless, the system is currently blocked. As explained in the introduction (Section 1.5) commercial suppliers do not have the finances to cater to individual needs. Governments are allocating funds, but the funds are limited, and not every community is reached. Complexities over local NGA supply and demand and the cooperation of multiple stakeholders needs to be addressed at the local level for investment to be successful (Salemink et al., 2017b).

Consequently, interventions are required to support infrastructure (Section 3.9). Rural communities and MBs want advanced broadband to experience the four-fold capital benefits, but the return of investment (ROI) is not enough to unblock the system (Section 3.6.3). Hence, what other capital resources (e.g. both financial & non-

financial) are required to unlock the system (RQ1). What interventions can be identified to get the system working for all stakeholders (RQ2 & 3). To set this thesis within the context of previous rural community broadband methodologies, relevant studies have been assessed to ensure cohesion within the research domain.

4.4.1 Local community (micro-level) – Previous rural broadband studies

The unit of analysis for this thesis is a rural community in Wales. The following (Section 4.4.2) will identify the methodological precedent for this study, in particular two studies were previously identified as having influenced this research (Section 3.2.4.2). Nevertheless, additional studies at the micro-level were identified in the literature review and will be summarised in this section.

Primary rural broadband studies within this domain are predominantly qualitative, although some quantitative studies have been deployed at the local level to analyse investment (Chakraborty et al., 2018) (Section 3.5.2). The local investment quantitative model used by the authors (2018) is complicated as the researchers worked for the statistical body (e.g. over 10 different data sets were used in the USA to evaluate local investment). Notwithstanding the lack of data access and time required for this approach, the focus of this thesis requires exploration and qualitative methods are better suited for this type of inquiry (Huberman & Miles, 2002).

Gerli & Whalley (2018) summarise that *"case study analysis is commonly employed to assess the impact of public and community-led initiatives in rural areas*" (p. 6). The case study method allows exploration and explanation of complex social phenomena in comparable yet different contexts (e.g. the digital divide) (p. 7). This is confirmed by the predominant use of case studies in the community-led initiatives (Bosworth & Salemink, 2014, June; Halseth et al., 2019; Salemink & Strijker, 2018; Wallace et al., 2015) (Section 3.5.1).

A review of relevant similar studies identified three in particular that investigated key elements of this study. Gerli & Whalley (2018) reflects an exogeneous supplier approach in examining public-private partnership (PPP) case studies. Ashmore (2015) examined an endogenous demand approach with community-led case studies, while an endogenous multi-stakeholder innovation management approach was studied in Hosseini et al.'s (2018) smart town case study. More specifically, the authors (2018)

use IM techniques as a coupled process *"comprises collaborative and co-creation activities among different stakeholders and parties in order to jointly leverage innovation"* (p. 247). This is an example of incorporating IM techniques to resolve the digital development in small towns (Section 3.7). These studies were used to inform the methodological approach to this thesis (e.g. NED & HVS).

4.4.2 Positioning of this research – Case study methodology

The original plan for this thesis was to conduct a mixed methods study to evaluate both NGA supply and demand (e.g. do rural communities & MBs want or need NGA) within a deep rural local context. However, due to the introduction of the Engagement Officers (EOs) to the case study area, this changed the research design to focus on a qualitative-only assessment given the time constraints (Section 4.10 & Appendix N for Demand Assessment). As discussed in the ontological and epistemological approach (Section 4.2), and the pragmatic nature of the research, the study required a method to explore the key stakeholders' individual views in both the supply and demand ecosystems.

Therefore, this study will draw on the precedent of Ashmore (2015) and Gerli & Whaley (2018) as an appropriate methodological design for studies of this type (Section 3.2.4.2). Both Ashmore (2015) and Gerli & Whalley (2018) are multi-method exploratory case studies to identify what critical success or failure factors are required to implement advanced broadband (product) to rural communities (market). As explained above (Section 4.4.1) case studies are commonly employed to assess impact of public and community-led initiatives in rural areas. Both Ashmore (endogenous demand-driven rural product to market analysis) and Gerli & Whalley (exogenous supply-driven rural product to market analysis) interviewed key stakeholders within the respective case study areas. This research requires interviewing neo-endogenous (NED) key stakeholders at the local level using the hybrid value system (HVS) approach to answer the RQs (Section 3.8.8.3). Hence, this research methodology is positioned within the case study context as the most appropriate research design for product to market analysis given the time constraints as previously mentioned.

4.4.3 Multi-capital, multi-stakeholder approach

For this thesis, the identification of human & social capital as critical success factors (CSFs) in community-led initiatives, outside of financial capital constraints, are a core assessment to answer RQ1 (Section 3.6.4). The IM literature identified new approaches for business management to engage multi-capital and multi-stakeholder ecosystems (Section 3.7). The methodologies created by Roche & Jakub (2017) to construct a mutual business model by identifying human, social, environmental and financial capitals "up front" will be modified for this study (Section 3.7.3.1). Notably, not all the methodologies created by Roche & Jakub (2017) will be used. Only the case study (named "Maua") methodology on how to get a "product" to a final few and hard to reach "market" will be used, because it focuses on human & social capital as "non-financial" assets. Other case studies created by Roche & Jakub (2017) analyse natural capital accounting measures and how to share financial distribution across the supply chain. These methodologies are considered out of scope for this thesis. Hence, the "product to final few market" Maua case study, focusing on the value of human & social capital, is most relevant to this thesis.

4.4.4 Mutual business method - Human & social capital case study

The mutual business (named "Maua") case study developed useful tools, based on previous methodologies, that can be tailored for this thesis. For example, Roche & Jakub (2017) adapted the World Bank Social Capital Assessment Tool (SCAT) (World Bank, 1999) to map the final few and hard to reach area and identify positive or negative social capital assets. The aim is to evaluate if the final few and hard to reach area is high or low in social capital which can affect the *fertility* of investment. Secondly, the mutual business approach developed the Hybrid Value System (HVS), adapted from the Hybrid Value Chain (HVC) (Drayton & Budinich, 2010) and similar to WEF Value Chain (Wynn & Jones, 2019), to identify and interview stakeholders to understand the individual pain points, and the contribution of capitals (assets) to resolve the problem (e.g. contributions of human, social, environmental & shared financial capital).

The goal of the Maua case study was to identify, manage and measure the human & social capital effects apart from financial-only metrics. The Maua case study is unique to the Mars Corporation, but the authors encourage others to adapt, trial and

test for their unique situation (Said Business School, 2017b). Due to the four-fold capital benefits as an outcome of rural SFBB (Section 1.4), the relevance of the four-fold capital mutual business approach complemented this study.

In summary, this is a snapshot of some of the qualitative methods previous studies have used to analyse rural broadband initiatives at the local community level. Qualitative research can be described as people or social research through interviewing techniques (Creswell, 2014). Quantitative research can be described as data research through a survey or experimental techniques (Jankowicz, 2000). Mixed methods is combining both qualitative and quantitative databases but has not been selected for this research (Creswell, 2015). This research requires interviewing relevant stakeholders; thus, a qualitative approach is identified. A detailed explanation of qualitative and multi-method research to inform the research design will be addressed the following (Section 4.5).

4.5 Research methodology

To develop an effective strategy to answer the RQs; it is essential to formulate a blueprint for the study (Maxwell, 2012; Saunders et al., 2016) which is the overall architectural research design (Collis & Hussey, 2014). Various methods and strategies are associated with data collection (Bryman & Bell, 2015; Collis & Hussey, 2014; Saunders et al., 2016). Thus, each methodology involves specific strategies to craft the research design. As explained in (Section 3.9), a qualitative approach to action the hybrid-value system (HVS) is best suited for this research. Thus, quantitative and mixed methods will not be discussed.

4.5.1 Strategy & objectives

Qualitative methods have a long history in the social sciences and have made substantive contributions to business management research (Cassell et al., 2006a; Runfola, Perna, Baraldi, & Gregori, 2017). More qualitative research is being called for to enhance new ways of seeing the world (Bansal et al., 2018; Cassell, Symon, Buehring, & Johnson, 2006b; Cornelissen, 2017). Qualitative research designs deal with people or groups of people within a society or organizational contexts and have numerous variations of approaches to studies which will be discussed in the following section (Bryman & Bell, 2015).

4.5.1.1 Strategy Selection

Saunders et al. (2016) suggest a summary of the most often used qualitative methods in business management research (e.g. case study, ethnography, action research, grounded theory & narrative inquiry). This section explains the various methods and provides an argument for selection.

Case study is a research strategy that utilises in-depth inquiry of a contemporary phenomenon in a real-life setting, using multiple sources of evidence (Eisenhardt & Graebner, 2007; Runfola et al., 2017). The strength of this approach is that theory can be constructed from multiple sources of evidence (Yin, 1994). Criticism of the strategy, such as that described by Mays & Pope (1995), can be overcome by testing content validity, internal validity and reliability at each stage of the research (Gibbert, Ruigrok, & Wicki, 2008). Case studies have proved beneficial in uncovering participants reactions and engagement with the topic or phenomenon (Collis & Hussey, 2014). Moreover, arguments are made that exploratory case study analysis, inductive theory building and thick description may be more suitable than quantitative to understand complex international business phenomena (Tsang, 2013). Given that a case study examines a complex social reality, based on whether it is examining the case for its own merits (intrinsic) or multiple cases (embedded/ instrumental) in order to create generalisations, they are all useful for inductive theory building as required by this study (Stake, 1995; Yin, 1994).

Ethnography research designs are often field studies where the researcher immerses themselves into a cultural or social group to study the traits and effects of the group (Bryman & Bell, 2015). Ethnographers primarily study people in groups and how they interact with one another in a shared space (Saunders et al., 2016). The focus of this research is not to study the group or cultural interactions, but to identify and measure stakeholder pain points and capital contributions. Therefore, ethnographic research strategy will not be used for this thesis.

Action research is often used by organisations to resolve organizational problems (Bryman & Bell, 2015). The researcher must have active participation within the organization to resolve the problem through continuous iterations of study (Saunders et al., 2016). Harris (2008) defines action research as *"an informed investigation into a real management issue in an organisation by a participating researcher, resulting*

in an actionable solution to the issue" (p. 1). This study does not require active participation in an organisation and therefore will not be considered for this thesis.

Grounded theory (GT) is both a theory and a methodology (Saunders et al., 2016). GT as a method provides guidelines for identifying categories, links and relationships. GT as a theory is generated by detailed coding process which provides a framework to understand the concept/phenomenon of study (Collis & Hussey, 2014). Due to the multi-method approach with *a priori* coding for this thesis, GT will not be used. However, thematic analysis is a technique used within GT, which will be utilised as an inductive exploration of the interview transcripts.

Narrative inquiry is capturing storytelling from participants (Cornelissen, 2017). The narrative could be considered as part of this thesis because interviewing relevant participants to understand the nature of the problem is part of the inquiry (Bryman & Bell, 2015). However, narrative inquiry, in its context, is focused on storytelling, which is not the primary goal of this research. Therefore, it will not be considered as a primary strategy for this thesis.

In summary, a case study approach will be used in a contemporary and real-life context of rural community stakeholder groups for multi-method analysis. Grounded theory as a methodology and potential theory development could have been incorporated if the study had started with GT. Nonetheless, time constraints do not allow for this method to be used. Action research, ethnography and narrative inquiry have been deemed inappropriate for this study and will not be considered further.

4.5.2 Case study design selection

A case study has been identified as the methodological approach required for this thesis and complimentary to the precedence set within rural community broadband studies (Section 4.4). A successful case study is a bounded system (Burns, 2000) that takes place in the field (Baxter & Jack, 2008; Yin, 1994) and within the phenomena's context (Gibbert et al., 2008) (Section 2.1.4).

Three notable case study scholars, namely Eisenhardt (1989), Yin (1994), and Stake (1995) advocate various research designs to develop theories (Brereton, Kitchenham, Budgen, & Li, 2008, June; Corley & Gioia, 2011). Each author developed a staged approach which can be summarised by Runeson & Host (2008) into five-stages: 1.

Case study design (e.g. defined objectives & planned case study). 2. Preparation for data collection (e.g. defined procedures & protocols). 3. Collecting evidence (e.g. execution with data collection for the case study). 4. Analysis of collected data, and 5. Reporting (p. 137).

Criticisms of Yin and Eisenhardt's prescriptive "positivist" protocols in case study research have been challenged recently to allow for more flexibility in the domain (Bansal et al., 2018; Cassell et al., 2018). For example, the "quantitative-like" methods used by Eisenhardt (e.g. grounded theory & multiple case studies) and Yin (e.g. case study protocols) have endured since the 1980s as a format to combat quantitative criticisms on qualitative validity, reliability and generalisation of findings (Pan & Tan, 2011). Nevertheless, Cassell et al. (2018) recent evaluation of qualitative business research is advocating a resurgence of Stake (1995) case study method which requires more flexibility and abductive approaches (p. 355). The authors (2018) summarise *"the abductive approach cherishes the flexibility of research design and views redirections of the case study as a source of theoretical insight and learning" (p. 355).* This flexibility stands in juxtaposition to Yin, who advocates strict adherence to research design (e.g. more positivist versus subjectivist approach).

The case study selected for this research is an intrinsic case study, because the "case itself" requires a holistic understanding to include "rich descriptions" versus the goal of attaining replicable generalisations attributed to Yin (Cassell et al., 2018; Siggelkow, 2007). Siggelkow (2007) argues a single case can be a powerful example (p. 20). Cassell et al. (2018) summarise their findings and suggest replacing inductive versus deductive, and positivist versus constructivist dichotomies with a *"new mindset and vocabulary, such as case-oriented analysis, abduction, deep structures and unobservables"* (p.356).

In summary, this research is a single, holistic, but flexible intrinsic case study by focusing on a final few and hard to reach rural community in Pembrokeshire, South Wales (Section 2.1.4). The focus is on the case itself to develop a holistic understanding of the complex exogenous supply ecosystem and how it interacts with the endogenous demand ecosystem (Section 3.8.8). This complex ecosystem engagement requires flexibility. The flexibility of a hybrid-abductive approach using *a priori* theory (e.g. human & social capital), but with an inductive exploration through

interviews should provide an overview to discover deeper structures and potentially unobservable phenomena. Thus, the case study design selected for this research will combine Yin (1994) desire to maintain validity by using a case study protocol, but with Stake (1995) abductive and inductive flexibility. The combination of using a protocol template for case study planning will be described in the following (Section 4.7)

4.5.3 Sample selection

Research sample selection is defined by probability sampling techniques (e.g. random selections of representative population studies; often associated with larger data sets for quantitative studies), or non-probability sampling (e.g. not random samples; & not dependent on population representation) (Bryman & Bell, 2015; Saunders et al., 2016). Probability sampling techniques are specifically designed to support quantitative surveys for larger population samples and are not suitable for this thesis. Non-probability sampling is not representative of population samples and will be considered through the various options (Jankowicz, 2000).

Non-probability sampling is defined as quota, purposive (e.g. critical case, extreme case, heterogenous, homogeneous, theoretical or typical case), and through volunteer (e.g. snowball techniques or self-selection) or haphazard sampling (e.g. for convenience) (Bryman & Bell, 2015; Saunders et al., 2016). Quota sampling is associated with quantitative studies which is not appropriate to this study (Jankowicz, 2000).

Purposive sampling requires the researcher's judgement in selecting the best-case scenario in locating the right participants to interview (Saunders et al., 2016). Purposive sampling is not considered statistically representative of a target population (Bryman & Bell, 2015). The selection criteria for this type of sampling is dependent on the justification of why the case was selected. The aim is to select information rich cases. Therefore, purposive sampling is relevant to this research.

The typical case aims to be "typical" or illustrative of the phenomenon of interest (Bryman & Bell, 2015; Saunders et al., 2016). Therefore, the strategy of this research is to identify a typical case which is illustrative of a final few rural community without NGA (Section 2.1.4). Heterogeneous (or maximum variation) or homogenous (or

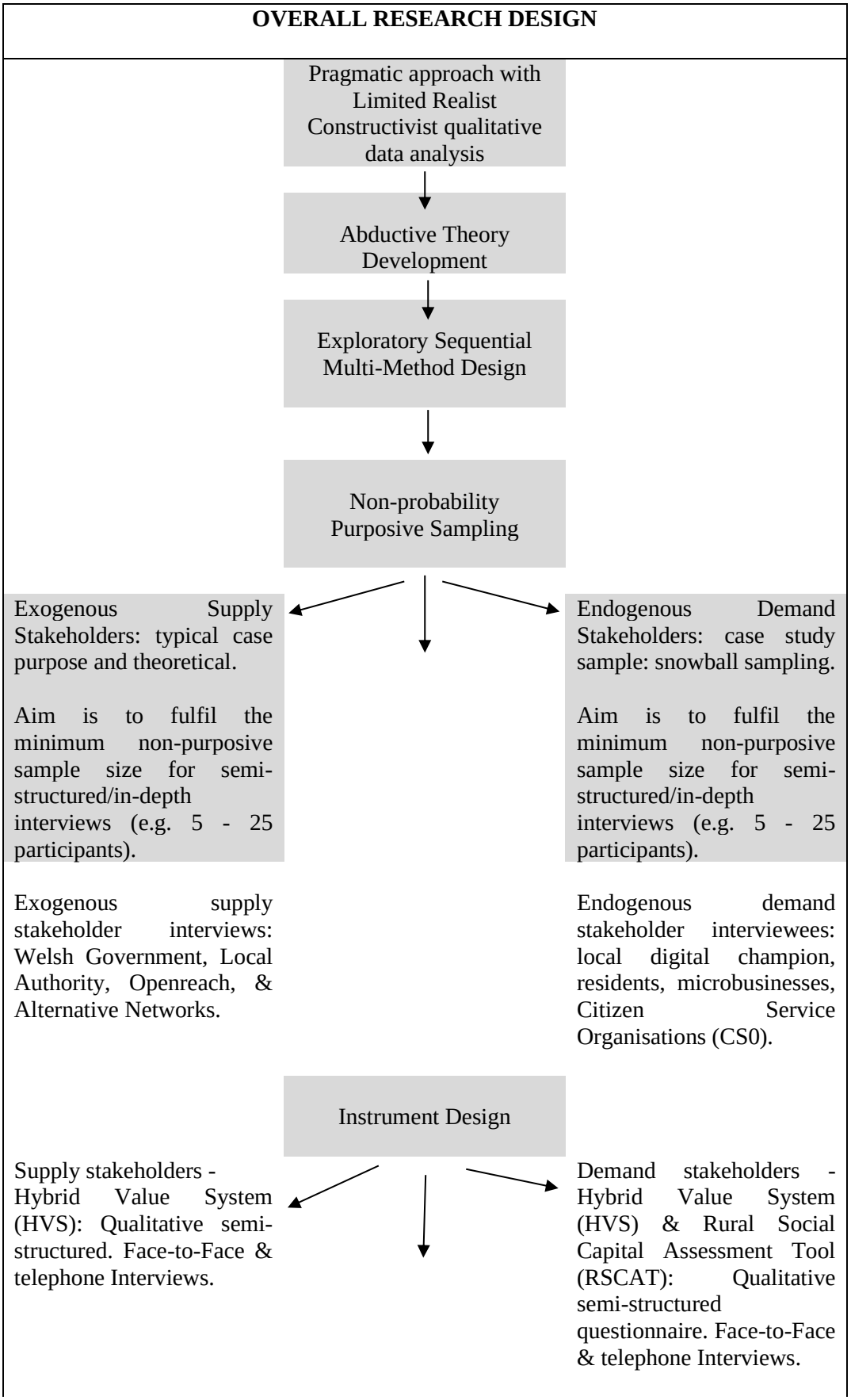
minimum variation) samples are not necessary for the research inquiry. Neither is a critical (dramatic event) or extreme case (deviant or unusual circumstances) (Saunders et al., 2016). This research could be viewed as a theoretical case because of the mutual business method, but it is not solely related to Grounded Theory (GT).

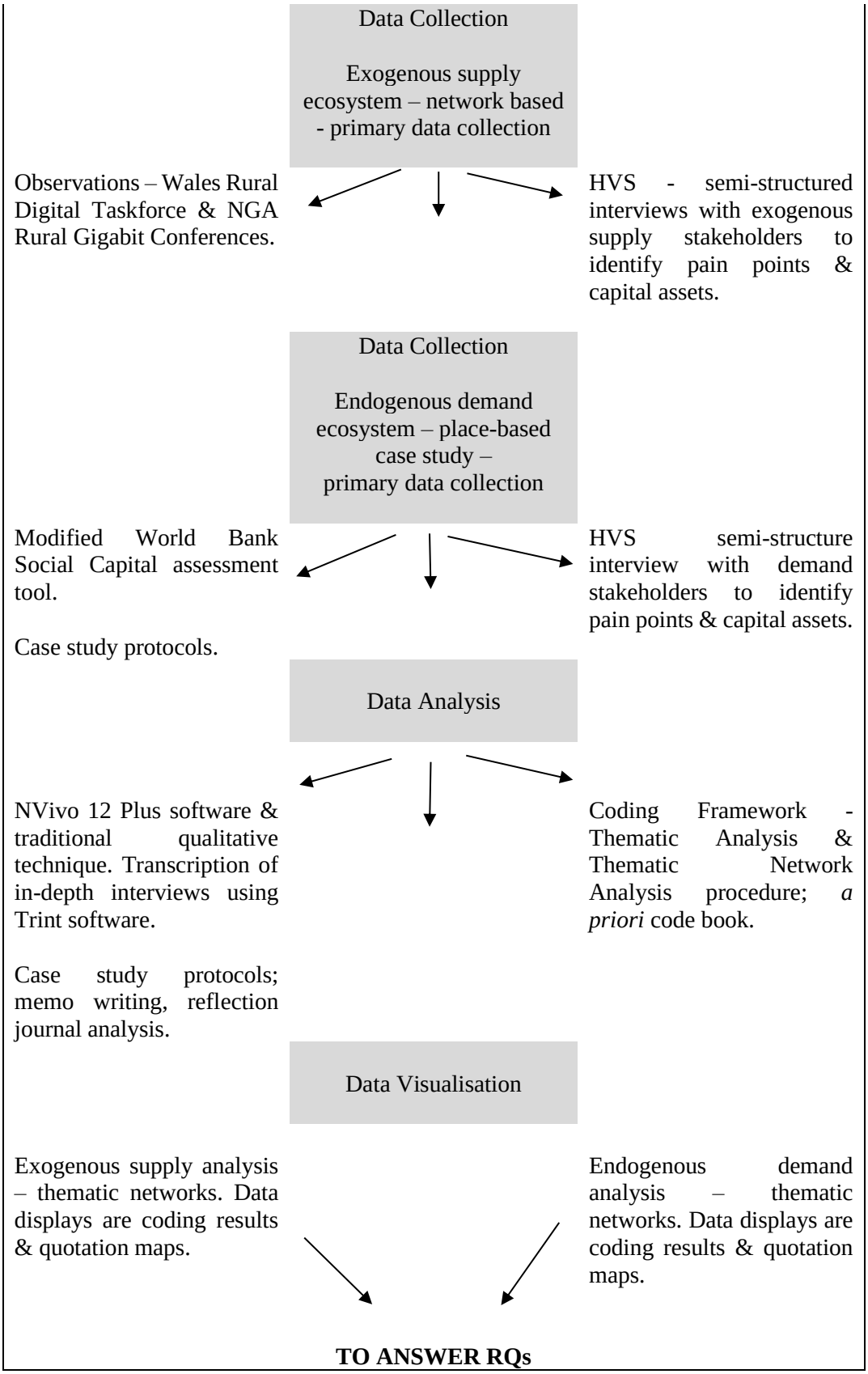
Volunteer sampling is used as a technique to identify and recruit participants (Jankowicz, 2000). Snowball sample selection is through introductions (Bryman & Bell, 2015). Relevant participants are identified and invited to take part, and in turn, are asked to recommend additional parties to contact. In contrast, self-selection is often by invitation, through advertising, for volunteers to take part in a survey and is not considered a relevant approach for qualitative interviews.

For the purposes of this study, a purposive typical case with a volunteer snowball approach will be used to locate relevant case studies and participants. A snowball approach was used to identify the LDC (Mr. G) who will act as a gatekeeper to the community (Section 2.1.4). Haphazard sampling will not be used for this thesis, because a targeted approach is required to focus the study into a final few and hard to reach rural area (Bryman & Bell, 2015). According to Saunders et al. (2016), non-probability sample sizes can be broken down into specific sample sizes related to the research approach. For example, in-depth semi-structured interviews recommend 5-25 participants to establish credibility for the study (p. 296).

In conclusion, a non-probability sample size of a minimum of 5-25 participants is required. The initial phase of this research requires in-depth HVS semi-structured interviews with both exogenous supply and endogenous demand stakeholders (Section 2.2 & 4.10.1). The second phase of this research requires a social capital assessment of the case study area (Section 2.1.4 & 4.10.2). Henceforth, the sample selections meet the recommended criteria for non-probability minimum requirements. The following (Section 4.6) summarises the overall research design for an in-depth intrinsic typical case study.

4.6 Overall research design summary - Flow chart




Data Collection
Exogenous supply ecosystem – network based - primary data collection
Observations – Wales Rural Digital Taskforce & NGA Rural Gigabit Conferences.
HVS - semi-structured interviews with exogenous supply stakeholders to identify pain points & capital assets.
Data Collection
Endogenous demand ecosystem – place-based case study – primary data collection
Modified World Bank Social Capital assessment tool.
Case study protocols.
HVS semi-structure interview with demand stakeholders to identify pain points & capital assets.
Data Analysis
NVivo 12 Plus software & traditional qualitative technique. Transcription of in-depth interviews using Trint software.
Case study protocols; memo writing, reflection journal analysis.
Coding Framework - Thematic Analysis & Thematic Network Analysis procedure; a priori code book.
Data Visualisation
Exogenous supply analysis – thematic networks. Data displays are coding results & quotation maps.
Endogenous demand analysis – thematic networks. Data displays are coding results & quotation maps.
TO ANSWER RQs

4.7 Case study protocol

A case study protocol template will act as a guide to increase reliability, validity, internal and external considerations (Brereton et al., 2008, June; Runeson & Höst, 2008; Yin, 1994). Runeson & Host (2008) state the case study protocol is *"a container for the design decisions on the case study as well as field procedures for carrying it through"* (p. 141). The case study protocol designed by Yin (1994) requires four essential procedures: an overview of case study project, field procedures, case study questions and a guide for the case study report (p. 63). Moreover, Brereton et al. (2008) advocate using a protocol template for case study planning, by combining Yin (1994) and Stake (1995). The authors suggest adding two validation sections to Yin's case study protocol: a divergence section (e.g. to record changes to the protocol) and a schedule section (e.g. to specify major milestones) (Brereton et al., 2008, June, p. 3).

The case study protocol is found in (Appendix G) and will be measured against Runeson & Host (2008) checklist (Appendix H). The following section details the case study protocol used for this thesis.

4.7.1 Overview of in-depth rural case study

Wales was identified in the introduction (Section 1.4) as an area for further investigation. Pembrokeshire was identified as a final few and hard to reach rural area in Wales (Section 2.1.4 & 2.3.3). To define "who, what, why and where" data to be collected and identify the best "data rich case" to discover the most amount of information relevant to answering the RQs (Yin, 1994). Hence, the following section details the answers to these defining questions. Prior to answering these questions, the criteria and method for the case study selection is explained.

4.7.1.1 Method for case study selection

The criteria for the case study was outlined in the research context (Section 2.1). The case study selection was dictated by the final few and hard to reach white premise areas identified as Ceredigion, Pembrokeshire and Powys (Section 2.3.2).

Geography and population criteria

As explained in (Section 2.1.4) the population size criteria are identified as the smallest geographic areas in Wales, namely "rural - hamlets & isolated dwellings in sparse

settings" or DEFRA coded (F2) criteria (Section 2.1.3). To recap, "sparse" dwellings represent the lowest population level and often struggle with the delivery of services because of the lack of commercial viability. Hence, the geographical and population criteria identifying the "final" few and hard to reach rural areas of Wales was used to confirm the case study area (Section 2.1.4).

4.7.1.2 Preliminary investigations

When conducting preliminary investigations into potential white premise areas in Ceredigion, Pembrokeshire and Powys (Section 2.1), Mr. G was contacted to inquire about Pembrokeshire. As explained in the research context (Section 2.1.4), one of the interviewees for the Microbusiness pilot project (2016), named Mr. G (Local IT Expert), had an IT Consultancy located in a deep rural hamlet in Pembrokeshire. It was through Mr. G, that this researcher was introduced to the Welsh Government Consultant (Mr. P) (Section 2.1.4).

During preliminary investigations into case study selection, two 90-minute telephone conversations occurred with a Mr. G (September/October 2018), and another 90-minute conversation with Mr. P (October 2018). The interviews with Mr. G uncovered a unique research opportunity.

4.7.1.3 Unique research opportunity – Splits-Ville

The interview discovered that one half of the hamlet (e.g. 20 properties) received SFBB by the end of December 2017, before Welsh Government funding stopped. The other half of the hamlet (e.g. 20 properties) did not receive SFBB. The second half of the hamlet lies in a valley with trees and no line of sight for mobile telecommunications. According to Mr. G this hamlet is "typical" of the final few and hard to reach rural areas for these reasons. Mr. G and Mr. P mapped the area. They discovered the second half of the hamlet has poor infrastructure because cables have been left unattended in the hedgerows and the expense of investing in upgrading the infrastructure was beyond what the community could afford.

The situation is currently on-going and provides a real-time single case study to investigate both supply and demand opportunities and challenges within a single geographic boundary. According to the Mr. G, over one-third of the properties in the area are microbusinesses. By focusing the research attention on one "typical" hard to

reach deep rural case, it was assessed as being suitable to provide a rich, in-depth and multi-source data investigation to provide a robust research case.

"Final few" and hard to reach rural area in Wales (who)

The 2018 Future of Telecommunication Infrastructure Report (FTIR) report identified 10% of deep rural communities are outside of "full fibre & 5G" funding for 2033 (Section 1.3). To bind the case study into a successful template, a number of options are being explored. Access to the case study research is through local gatekeepers (e.g. Mr. G & Mr. P). In turn, the gatekeepers provided additional people to contact, to identify the right case study options.

Case Study – Unique research opportunity (what)

A single case study can provide in-depth, rich and multiple sources of data to extract and answer the RQs (Bryman & Bell, 2015; Burns, 2000; Yin, 1994). A comparative case study can provide a stronger reliability and validity framework (Yin, 1994).

Background to "Splits-Ville" (where)

To provide a background to the study, a second 90-minute interview took place with Mr. G (October 2018). The Pembrokeshire hamlet will be named Splits-Ville A (SV-A) which denotes the half of the hamlet who received SFBB before the funding cut-off, and Splits-Ville B (SV-B) is the half of the hamlet that did not receive SFBB.

Splits-Ville A has approximately 20 properties. It is made up of Welsh and English residents. English residents purchased second homes and have since retired to the area. The village used to have a pub and post-office, but the business burnt down in 1965 and has not been replaced. There was a primary school for children, but it closed 15 years ago. There was a local church which was supported by surrounding farmers, but the decline in the population has seen this close. The church building is now a workshop and acts as a makeshift community meeting place as and when required. The council does not refer to the area as a hamlet or village, but as open countryside. To the residents however it is still a village with the proximity of the houses and the community that lives there. A third of the residents run microbusinesses. The MBs comprises of two carpenters, a garden design company, a leather making business, an

IT consultancy, a translator who works from home and local women who bake goods and sell crafts.

The value of human & social capital (why)

In 2017, the Mr. G became the Local Digital Champion (LDC) for Splits-Ville and organized, on behalf of the community, to solicit the Welsh Government to get SFBB. The LDC has been identified as a critical success factor in rural broadband literature (Section 3.6.4). This engagement can be labelled as the value of human capital (e.g. IT skills is CSF) and social capital (e.g. the value of relationships, networks & trust) to make things happen for all stakeholders (Section 3.6.5 - 3.6.6).

Mr. G (LDC) had the IT skills to profile the community. The volunteer work is a non-financial value-add. The process took 18-months. Mr. G managed to get all the critical stakeholders, the Welsh Government, BT and local planning, around the table to determine what can be done to get SFBB to the rural community. Mr. G had completed the technical mapping and had spoken to the resident farmers. Mr. G's proactive volunteer work reduced the consulting and surveying costs for BT. BT arrived in July 2017 to place a fibre-to-the-cabinet (FTTC) outside of one of the homes but had not sought the owner's permission. The owner complained, which resulted in another six-month delay to re-visit the survey and planning.

In December 2017, the new FTTC location was secured, and the new SFBB went live on December 20, 2017. The residents did not want to get involved, because of the technical expertise required. Nevertheless, they were grateful to have the reliability of SFBB. Residents do not regard speed for speed's sake, but that the speed provides the reliable service they want. This result is validated in previous rural SFBB studies (Ashmore et al., 2015) (Section 3.5.1). Residents can select from speeds up to 35 Mbps for approximately £25-30/month or up to 80 Mbps for £45/month. Vodaphone has recently connected the area with 4G service, so the residents are satisfied with the results.

Splits-Ville B is part of the community, but the other 20 properties are in a valley covered with trees. There is a church which is still active and opens once a month to provide services to the community. The church was the focal point to the surrounding

farms and homes. There are three farms surrounding the church and other local microbusinesses who do not have decent broadband.

The location of SV-B makes it a "not spot" or "final few" and hard to reach. The residents have limited options. Satellite is expensive with limited use. 4G is in the area, but residents need to be higher up to see the mast to get the fast speeds. The community farmers have agreed to dig the trenches, and there are poles overhead which can be used to supply fibre. The human & social capital of Mr. G and the local farmers produces the cooperation and volunteerism to reduce costs and contribute to solutions (similar to previous community-led initiatives, Section 3.5). BT does not have the social capital (e.g. trust & networks), so partnering with local LDCs can be a mutually beneficial non-financial value-add.

4.7.1.4 Other "demand-side" case study research

The original research plan was to include separate supply and demand case studies. In preliminary discussions with Mr. P (Welsh Government) in October 2018, the intention of the 90-minute telephone conversation was to discuss "demand-side" opportunities.

During the telephone call, Mr. P advised Wales is above the national average for SFBB take-up rates. Alwen Williams (Managing Director of BT Wales) cited Think Broadband take-up statistics at 20% (Digital Communities Wales, 2016). Mr. P advised investigating Gwynedd in North Wales because it has the highest take-up of SFBB. According to Mr. P, in 2012, the Welsh Government asked all the local authorities in Wales to provide a business case for their community to be the first to receive SFBB. Gwynedd won. The Gwynedd team asked to come to Cardiff to meet some influencers, namely the Chief Information Officer (CIO) and other stakeholders.

The proactive approach and their subsequent development of a dedicated digital training programme appear to have influenced the successful take-up rate. The Welsh Government subsequently invested £12 million into a Broadband Exploitation Programme, modelled after Gwynedd success. Gwynedd is in North Wales which is further geographically from this researcher. Nevertheless, the Gwynedd proactive approach to inspire demand and take-up of SFBB is notable.

In summary, the purpose was to investigate case study opportunities and discover a typical case, but with the opportunity to extract information rich and relevant data. The Splits-Ville case study identified above combines supply and demand opportunities and challenges into a single case study. Previous studies have focussed on SFBB. This thesis is focusing on NGA "full-fibre & 5G" supply and demand awareness and challenges. The aim of this study is to explore what capital resources are required to support infrastructure to enable NGA to be viable for rural communities and microbusinesses (RQ1). This intrinsic case study allows engagement with a final few and hard to reach area in Wales and to investigate how human, social, environmental and shared financial capital can contribute to unblocking the system for all stakeholders. A single case study analysis aims to discover how ICT suppliers can engage with rural community stakeholder groups and will multi-stakeholder engagement resolve the challenges (RQ2 & 3).

4.7.2 Field procedures

As the field procedures were undertaken at interlocking periods of time, they are organised according to the data collection methodology (Section 4.8). Access to relevant exogenous supply stakeholders and endogenous demand stakeholders are detailed in (Procedures III-IV).

The overall field procedures are organised according to the observations and interview summary guide (Section 4.8.7, Table 4.3). Field procedures include time, expenses, data management and storage (Stake, 1995) and are summarised in Swansea University Participation Sheet including General Data Protection Regulation (GDPR) guidelines (Appendix E). Basic resources, geographical access and contingency planning across all data collection procedures (III-VI) are summarised as follows:

4.7.2.1 Resources & geographical access

Resources required to conduct the interviews were Sony digital voice recorders. Data organisation is with NVivo Pro 12 and Sound Organiser software. Trint software was used for transcription. Due to the COVID-19 outbreak at the time of data collection, later interviews were conducted by telephone. Previous data collection was face-to-face (F2F). Researcher notebooks were kept for reflection on academic learning (e.g. what has gone well, what has not gone well, what adjustments need to be made, what has been learned, how to improve & so forth) (King & Brooks, 2018; Saunders et al.,

2016). Manual notetaking was conducted during Taskforce and event meetings, and if the interviewee did not want to be digitally recorded. Expenses and travel to and from conferences, event meetings, and Splits-Ville case study area were researcher's own.

4.7.2.2 Contingency planning

Health and safety considerations in the event of an emergency (e.g. accident or illness) were mitigated through information sharing (e.g. family notified as & when attending Splits-Ville). The researcher is a member of RAC (e.g. breakdown assistance) and has first aid kit, blanket, flashlight, mobile phone charger and water in the vehicle. No demand interviews were conducted without introductions from the Mr. G (gatekeeper). No interviews were conducted in remote or unknown locations. Interview data collection is January-March 2020. Swansea University ethical approval (Appendix E) and Participant Consent form is documented (Appendix F).

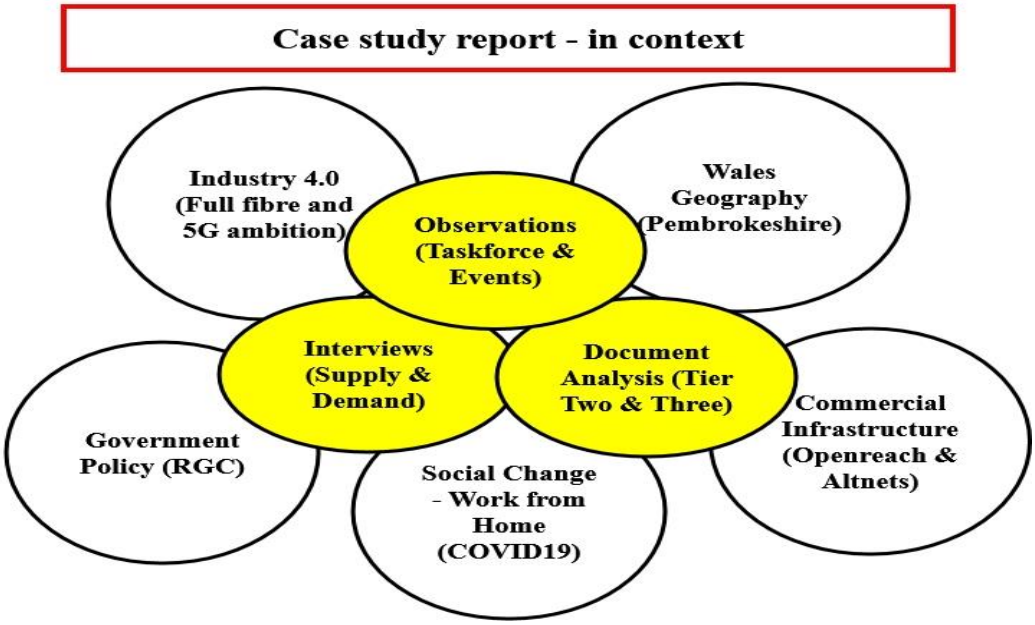
4.7.3 Case study questions

Due to the complexity of the exogenous supply and endogenous demand stakeholder ecosystems, a phased procedural approach and explanation of the semi-structured instrument guides will be addressed in the following (Section 4.10) and presented in (Appendix I).

4.7.4 Guide for case study report

The guide for the case study report encompasses the three spheres of interlocking data collection: observations, interviews and tiered stages of document analysis within research context (Figure 4.2).

Figure 4.2 Summary of case study report within research context



These three spheres will form the basis and organisation of the nation-level contextual findings reported in (Chapter Five). Due to the volume of data collection, details for each sphere are presented below in data collection procedural methods (Section 4.8).

In summary, the organisation of the data collection across both exogenous supply and endogenous demand stakeholders will follow a phased procedural data collection strategy (Section 4.8) within the research context (Section 2.1) and will be presented as such in (Chapter Five).

4.7.5 Divergence - Change record

Divergence records will be incorporated as the data collection commences. For example, there is a notable divergence from the intended data collection plan modelled after the conceptual framework (Section 3.8.8). Originally, the conceptual framework was to investigate both exogenous supply and endogenous demand stakeholders. More specifically, as a result of observations during the Taskforce in September 2019 (Section 4.8.4) a novel exogenous supplier intervention has altered the focus of this research from a “bottom-up” grassroots initiative to a “top-down” intervention. This will be explained further in the data collection methods (Section 4.8) and the effect on the instrument design (4.10). Details of the intervention will be explained in the nation-level contextual findings (Chapter Five).

4.7.6 Schedule - Milestones

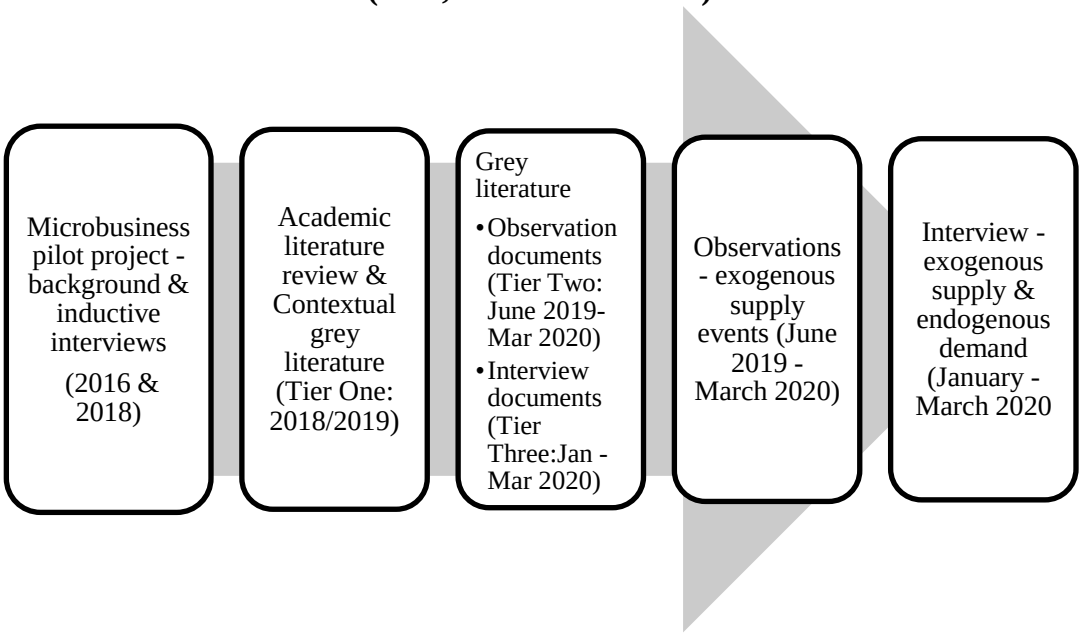
Time scales for data collection will be presented in a summary of the data collection methodology (Section 4.8.7, Figure 4.4). As this is a complex and interconnected ecosystem analysis involving three spheres of data collection, the time schedule will be updated accordingly and summarised in the case study protocol (Appendix G). In sum, the case study protocol (Yin, 1994) is used for reliability, reflection and credibility, but with divergence records and scheduled milestones to allow flexibility (Stake, 1995).

4.8 Data collection methods

The following section outlines the procedures used to collect the data as summarised in the overall research summary flow chart (Section 4.6). As the field procedures were undertaken in parallel at the time of the three spheres (Figure 4.2) they are organised according to the data collection methodology. The time frame for data collection captures the chronology and interlocking data (Figure 4.3).

Figure 4.3 Data collection process & timeframe

Relating to the three spheres: observations, interviews & document analysis (2016, 2018/2019 & 2020)



To summarise, background information from interviews that formed part of the context-setting were undertaken in 2016 and 2018. These were essential to identify the case study area and Mr. G and Mr. P as gatekeepers (Section 2.1.4). Observation data collection timeframes are within the Rural Gigabit Connectivity (RGC) Programme

roll-out in June 2019 to March 2020. The formal interview data collection commenced in January to March 2020. The data collection methodology therefore is detailed below from the following sources:

I. Academic literature review – collected up to May 2019 (pre RGC rollout)
II. Grey literature review – collected 2018/2019/2020 (pre & post RGC rollout)
III. Microbusiness pilot project & case study selection – 2016 & 2018
IV. Observations at exogenous supply stakeholder events – 2019/2020
V. Interviews with exogenous supply stakeholders – January – March 2020
VI. Interviews with endogenous demand stakeholders – January – March 2020

In conclusion, and to confirm the rationale for the order of data collection. The broader context of the RGC programme was selected for observation because it provides valuable context that directly influences the case study area. The following section details (Procedure I-VI).

4.8.1 Procedure I: Review of academic literature

The review of the academic literature is detailed in (Section 3.2) and covers the timeframe up to the RGC roll-out (May 2019).

4.8.2 Procedure II: Review of grey literature (Tier One, Two & Three)

*Contextual g*rey literature (Tier One) was collected prior to the RGC programme (May 2019). This literature includes relevant contextual reports from international, national, regional, local governmental bodies, media and so forth which were introduced in the literature review (Section 3.2, Table 3.3).

Observation grey literature (Tier Two) was collected as a result of attending conferences, governmental event and Taskforce meetings (June 2019 – March 2020). Relevant documentation, such as meeting agendas, manual notetaking, PowerPoint presentations, references and reports were collected for analysis. Details of the observation data collection are outlined below in Procedure III. This data was collected electronically and in hardcopy and summarised in (Table 4.2).

Interview grey literature (Tier Three) discovered during one-to-one interviews (January - March 2020) will be included in the nation-level contextual findings (Chapter Five, Section 5.11).

4.8.3 Procedure III: Microbusiness pilot project & case study selection

As explained in the research context (Section 2.3.6.3), a 2016 Microbusiness pilot project revealed numerous insights and data relevant to this thesis. It was from these initial investigations that this researcher interviewed Mr. G and who later became the LDC for SV-A (Section 4.5.2). The first contact with Mr. G was in 2016, and subsequently in 2018 for case study selection. The relevant findings will be presented in (Chapter Five, Section 5.8.1).

4.8.4 Procedure IV: Observations at exogenous supply stakeholder events

Access to observations, networking for interviews and document collection (Tier Two) was through relevant conferences and governmental events. An invitation to attend the Taskforce (September 2019) followed the INCA Rural Gigabit conference (May 2019). The invitation was extended by a Welsh Government representative upon networking and discussions at this event. Notes were taken manually at the following events:

1. **Observations from Regional Studies Association (RSA) Wales conference** on *"Digital technology, productivity, gains and regional resilience"* (2019, May 22) in Cardiff, South Wales. The *purpose* of the conference was to present the findings from Cardiff University five-year Superfast Broadband Business Exploitation Programme and encourage the next round of engagement for NGA supply and demand opportunities and challenges in Wales. *Speakers* included academics from Cardiff University involved in the Superfast Broadband Business Exploitation programme, but also studies on SME resilience, regional resilience, and Artificial Intelligence (AI) automation in support of Industry 4.0. Welsh Government speakers included the Director of Superfast Broadband Exploitation programme, and the Welsh Assembly Member (AM) Lee Waters, Deputy Minister for Economy and Transport. Commercial suppliers included Amazon Web services to promote cloud computing (demand exploitation), and CEO from Alternative Network provider explaining opportunities and challenges of deploying advanced broadband in Wales (supply exploitation). *Attendees* included academics, industry professionals, supplier and government representatives. Notes were taken manually following the agenda, which included ten speakers. Networking to

establish contacts for interviews, and data collection of recent Superfast Broadband Business Exploitation reports.

2. **Observations from Independent Networks Cooperative Association (INCA)** Conference Rural Gigabit Future: Rural Wales (2019, May 24) in Conwy, North Wales. The *purpose* of the conference was to update interested parties on DCMS Rural Gigabit Connectivity (RGC) programme. *Speakers* included an INCA consultant active in providing "full fibre & 5G" to white premises in Welsh rural communities. A UK Government speaker (DCMS Programme Lead for RGC) explaining BDUK name change to "Building Digital UK" and how the government plans to roll-out the next wave of funding. A Welsh Government speaker responsible for rural gigabit future and additional Welsh Government funding. An Openreach speaker presented its problem stack for Local Full Fibre Networks (LFFN), RGC solutions, providing wholesale solutions for Communication Providers, and the Community Fibre Partnership (CFP) to focus on the final few and hard to reach. An Altnet speaker presented wireless and TV whitespace technologies and sought partnerships for the new wave of funding. Various financing options were presented, including local authority financing. *Attendees* included interested parties, such as local authorities, alternative networks, but no other academics apart from this researcher. An observation of event sponsorship included HellermannTyton (global network equipment suppliers), and Fibre Speed (Welsh Government spin-off initiative operating dark fibre in North Wales). Manual notes were taken following the agenda, and networking for interview contacts and collection of PowerPoint slides for document analysis.

3. **Observations from UK5G Rural Gigabit Connectivity conference** (2019, June 11) in Newport, South Wales. The event was hosted by the Knowledge Network (KTN) and Innovate UK. The *purpose* of the conference was to engage interested parties to bid for the next round of 5G funding. *Speakers* included DCMS who covered UK5G testbeds and trials to date. Presentations included 5GRIT (5G Rural Integrated Testbed) and 5G Rural First. *Attendees* included academics, alternative network suppliers, local authorities, and Mobile Network Operators (MNOs). The *aim* of the conference was to showcase UK5G thinking and work to date to inspire

multi-stakeholder collaborations for the next round of funding to develop 5G supply and demand across the UK.

4. **Observations from the Wales Rural Digital Taskforce** (September 2019 – March 2020). The *aim* is to identify solutions to broadband coverage deficits. The *objective* is to provide immediate solutions to those deficits in Wales. The *purpose* is to recommend practical solutions, report to government on recommendations and actions, act as a liaison with telecommunication industry to overcome barriers, and eventually assist and inform future procurement routes and interventions. The *attendees* include the Welsh Government officials tasked with rolling out broadband infrastructure to rural communities. Local authorities, who represent the majority of white premises in Wales (Section 2.3), and who are proactive in trying to bridge the digital divide with the engagement of new strategies and technologies. The Taskforce began in September 2019 and will continue through to 2021 as the RGC programme rolls out. The *frequency of meetings* was monthly and approximately two hours in length. The *agenda* covered updates and actions from previous meetings, a roundtable update from each local authority with the aim of sharing best practice. Observation data collected include meeting agendas, action plans, researcher's manual meeting notes, and any presentation data that are non-confidential. Confidential materials will not be included in this research. This researcher was the only academic invited to attend these meetings.

5. **Observations from Welsh Government Broadband Funding Information Event** (2020, 22 January) in Cardiff, South Wales. The *purpose* of the event was to introduce the New Community Broadband Fund of £10 million to be deployed over the next three years with the explicit focus of reaching the remaining 95k white premises. The fund is aimed at local authorities and social enterprises. *Speakers* included Welsh Government Infrastructure team giving an update on existing schemes and rollout, an overview of the data, the opportunity that presents, and proposed future plans to reach the final 95k. *Attendees* included alternative network suppliers, local authorities, social enterprises and a few academics. Data collection included all the PowerPoint presentations, including the introduction of

the PCC local authority approach, question and answers from both South and North Wales events, and a list of attendees.

In summary, detailed findings from the observation data will be included in the nation-level contextual findings (Chapter Five) and in the local-level analysis (Chapter Six). A chronological summary of the data collected from the observation data is detailed in the following (Table 4.3).

Table 4.3 Chronological summary table of data collected from observations (Conferences & Welsh Government events: June 2019 – March 2020)

Observation	Date	Data Collected	Method (Tier Two grey literature)
RSA Wales Conference	22 May 2019	Conference Agenda, Manual note taking, Superfast Broadband Exploitation Programme Reports, Networking for interviewee contacts	Hard copies of reports.
INCA Rural Gigabit Conference	24 May 2019	Conference agenda, manual notes, networking for interviewee contacts, Openreach PowerPoint slide, Welsh Government PowerPoint slide	Hard copy & electronic copies. Including INCA website, events, reports, news updates: (www.inca.coop).
UK5G Rural Gigabit Connectivity (RGC) Conference	11 June 2019	Conference Agenda, manual note taking, follow-up on references mentioned: 5GRIT, 5GRural First & UK5G Innovation Network website, newsletter & magazine (members only)	Hard copy & electronic websites: 5grit.co.uk, 5gruralfirst.org & uk5g.org.
Welsh Government: The Taskforce	4 September 2019	Meeting agenda – includes aims, objectives, terms & reference, attendees. Manual notetaking.	Hard copy & electronic copies for agenda & follow-up meeting notes. PCC Engagement Officer & Pilot scheme initiative (maps & outlines). Electronic Business News Pembrokeshire article.
	15 October 2019	Meeting agenda – follow-up action from previous meetings, round table updates, barrier busting issues, future collaborative working. Manual notetaking.	Hard copy & electronic copies for agenda & follow-up meeting notes. Public Health England's Centre for Radiation, Chemicals & Environmental Hazards (PHE-CRCE) for 5G health concerns.

	25 November 2019	Meeting agenda – follow-up action from previous meeting, new funding update, round table, data capture, collaborative working, communications. Manual notetaking.	Hard copy & electronic copies for agenda & follow-up meeting notes.
	15 January 2020	Meeting agenda – follow-up previous meeting, roundtable updates, DCMS barrier busting presentation, Community Broadband Grant Supplier Events. Manual notetaking	Hard copy & electronic copies for agenda & follow-up meeting notes. Updated PCC pilot project (maps, statistics).
Welsh Government: Broadband Funding Information Event	22 January 2020	Meeting agenda – PowerPoint slides for overview and Pembrokeshire County Council initiative. Manual notetaking.	Hard copy & electronic copies for PowerPoint presentations, attendees list and question & answers from both South & North Wales events.
Welsh Government: The Taskforce	26 February 2020	Meeting agenda – follow-up previous meeting, roundtable updates, PSBA (public sector broadband aggregation) for public sector broadband network update. Manual notetaking.	Hard copy & electronic copies for agenda & follow-up meeting notes. Referenced website: PSBA.gov.wales.

** Independent Networks Cooperative Association (INCA), Regional Studies Association (RSA).*

4.8.5 Procedure V: Interviews with exogenous supply stakeholders

Semi-structured interviews were undertaken with exogenous supply stakeholders relevant to the case study area. Access to exogenous supplier interviews were identified from the conference and taskforce meeting data listed above (Section 4.8.4, Procedure IV).

The purpose of the interviews is to identify individual pain points and capital asset contributions. Details of the semi-structured interview guides are in (Section 4.10.1). The data from these interviews is analysed to provide answers to (RQ1, 2 & 3).

The rationale for the HVS instrument design for Procedure V is found in (Section 4.10). The *a priori* coding to inform the questions is presented in (Section 4.11.2). The interview schedule is presented in the following (Table 4.4). Interviews are digitally

recorded upon consent (Appendix F) or through manual notetaking. Field procedures for all interviews are detailed in (Section 4.7.2).

4.8.6 Procedure VI: Interviews with endogenous demand stakeholders

Semi-structured interviews were conducted with relevant endogenous demand stakeholders identified in the case study area. Access to the endogenous demand interviewees is through Mr. G (Section 4.7.1). Interviews with Citizen Service Organisations (CSO) will take place after the initial rural community interviews because they need to be identified as active contributors in the case study area.

The purpose of the interviews is to identify individual pain points and evaluate the social capital "fertility" in a final few and hard to reach rural area (Section 3.6.6). The World Bank Social Capital Assessment tool (SCAT) was modified to identify the various assets within the community to answer (RQ1, 2 & 3).

The rationale for the HVS and Rural Social Capital Assessment Tool (RSCAT) instrument design for Procedure VI is explained in (Section 4.10). The *a priori* coding to inform the questions is detailed in (Section 4.11.2). The interview schedule is presented in (Table 4.4). Interviews are digitally recorded with upon consent (Appendix F) or through manual notetaking. Field procedures for all interviews are detailed in (Section 4.7.2).

4.8.7 Summary observations & interview guide

The observation and interview guides are symbiotic and summarised in the following (Table 4.4). The Rural Gigabit Connectivity (RGC) government and commercial policy and funding interviews dictates the influence on the local community. Hence, the broader national context of the RGC programme needs to be understood first.

The local rural community in-depth case study was designed to allow for a more nuanced picture of what is happening in social reality within a naturalised setting (Bryman and Bell, 2007) (Section 4.5.2). The observation and interview guides, adapted from (Gerli & Whalley, 2018; Henderson & Roche, 2019) are summarised in the following (Table 4.4).

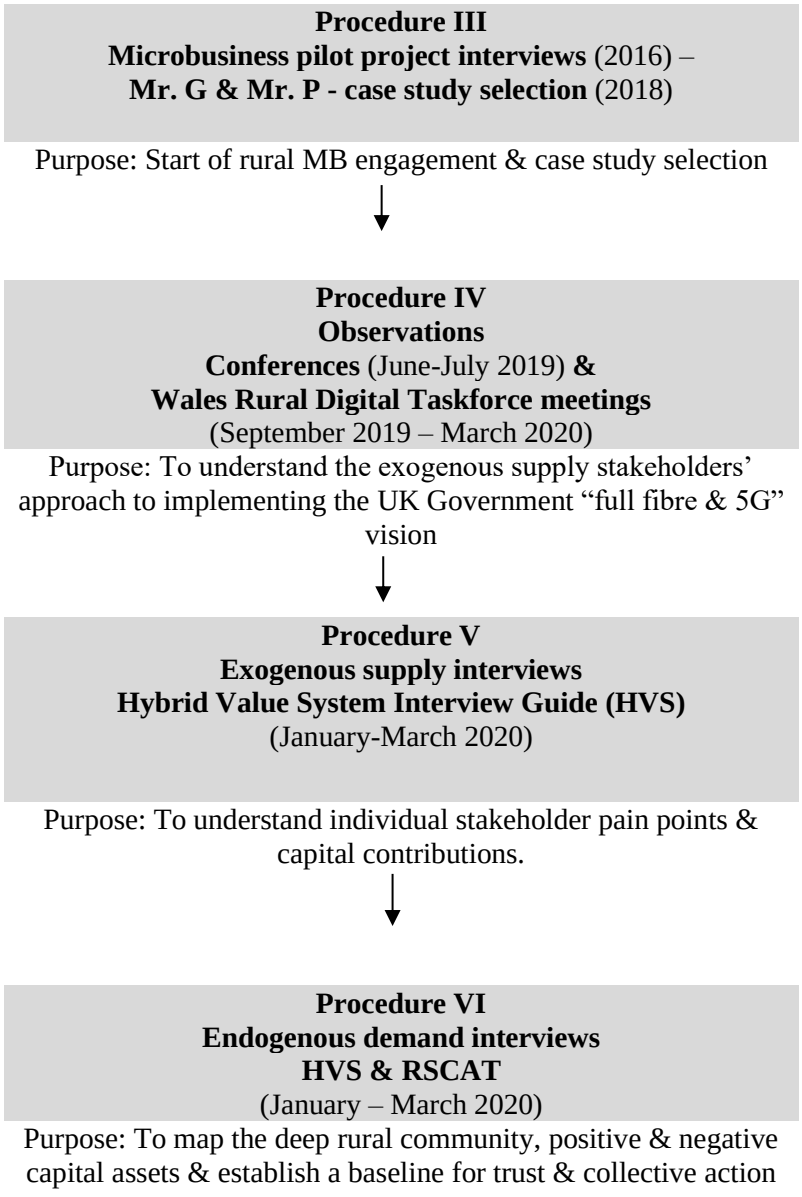
Table 4.4 Observations & interview guide

Description	*Data Source*	*Number of interviews*
Nation-level **Macro Governmental and Commercial Context**		
UK Government (DCMS/BDUK) to Wales	Observations at conferences & the Taskforce	Related to Wales Rural Gigabit Rollout (1)
Welsh Government	Observations at conferences, the Taskforce & HVS supply interviews	Related to Wales Rural Gigabit Rollout (4)
Openreach/BT		Related to Wales Rural Gigabit Rollout (1)
Alternative networks (Altnets)		Related to Wales Rural Gigabit Rollout (2) CEO INCA and Altnet
Local-level **Micro In-depth Case Study Context**		
Local Exogenous Supply Interviewees		
Local Authority – Pembrokeshire County Council (PCC)	Observations at the Taskforce, Welsh Government Supplier Event & HVS supply interviews	PCC leader (1)
		Local Authority IT specialist (1)
		Local Authority Engagement Officers (2)
Alternative networks (Altnets)	Observations at conferences, the Taskforce & identified in RSCAT interviews	Altnet CEO (1). Altnet business development (1)
Openreach – Community Fibre Partnership (CFP)	Interviews	CFP (2)
Local Endogenous Demand Interviewees		
Local digital champion/s (LDCs)	Interviews	Splits-Ville A & B (2)
Rural MBs & resident		IT Consultancy (2) Leather making (1) Ward Councillor (1) Copy writer (1) Farmers (2)
Rural CSOs	Identified in RSCAT Interviews	National Farmers Union (NFU) (1) Young Farmers Association (1)

**Independent Network Cooperative Association (INCA), Citizen Service Organisations (CSOs), Microbusinesses (MBs).*

In summary, the macro *nation-level* contextual governmental and commercial supplier initiatives will inform the micro *local-level* context of the in-depth rural case study. The remaining data collection (Procedures III-VI) will follow a phased procedural approach to capture the chronological flow within the interlocking spheres (Figure 4.4).

Figure 4.4 Phased procedural flowchart (III-VI)



4.9 Ethics, access & timeframe

Ethical considerations include informed consent and review board approval, confidentiality, handling of sensitive information and feedback (Runeson & Höst, 2008). Ethical considerations have been confirmed through the Swansea University Ethical Guidelines and are included in the letter of introduction to ensure participants are aware and informed of the procedures for this research. The procedures include anonymity, confidentiality, consent, data recording, data protection, data management and the participants right to withdraw. The Swansea University Ethical Approval, consent forms, data protection procedures, and the letter of introduction are available

in the (Appendix E & F). Access to all stakeholders was explained in (Section 4.8). Observations and interviews are in person, email or by telephone (see field procedures Section 4.7.2).

Cross-sectional time frames are "snapshots" of a specific time. Longitudinal studies are "diaries" of more prolonged engagement to study changes in a specific event or location (Saunders et al., 2016). This research is a cross-sectional study over a specific time frame, primarily June 2019 to March 2020, although an accumulative view of interviews conducted from 2016, 2018 and 2020 respectively could be considered longitudinal. Nonetheless, the primary boundary of this research is within the context of RGC programme from June 2019 to date (Section 2.3.1).

4.10 Instrument designs

The instruments were designed from definitions and concepts identified in the literature review (Section 3.9.1, Table 3.15). To reiterate, and for clarification of terms, the definitions for capitals as *assets/resources* and *inputs* versus the four-fold capitals as *benefits* and *outputs* were intended to be measured separately (Section 3.8.8.3, Figure 3.6). The clarification of four-fold capital assets (inputs) and benefits (outputs) are important for data analysis and answering the RQs. Nevertheless, a divergence to the intended research design regarding measurements of four-fold capital benefits (outputs) will be addressed in (Section 4.10.4).

Previous research is used to inform the instrument design. Definitions from the rural broadband literature were identified in the literature review (Section 3.6.7, Table 3.11). Critical success factors (CSFs) are included to ensure best practice and variables to be measured (Section 3.6.4). Methodologies and question design from other surveys are considered to inform the interview guides (e.g. World Bank Social Capital Assessment Tool (SCAT), OECD Social Capital database, Flora's Community Capital Framework (CCF)).

The original research design following the conceptual framework (Section 3.8.8) included an NGA demand awareness intervention and self-assessment. The instrument for the NGA demand intervention was constructed using a modified Cantril's self-assessment scale (Appendix N). However, after a series of divergence adjustments,

this section will now form part of future recommendations (Chapter Eight). The adjustment rationale is explained in divergence change record (3) (Appendix N).

4.10.1 Hybrid Value System (HVS) – Semi-structured interviews

The first step in the mutual business methodology is the HVS to identify individual stakeholder pain points and capital contributions in resolving supply and demand challenges. *A priori codes* from the literature is used to guide the questions in relation to the four-fold capitals as assets (Section 4.11.2, Table 4.6).

4.10.1.1 Pilot testing

The HVS instrument was pilot tested through a debrief panel to ensure the continuity and relevance of questions (December 2019). The debrief panel included the researchers external Supervisors who provided advice and coaching on how to construct the interview guide into a conversational format. The HVS instrument was timed to ensure questions can be answered within a reasonable time frame.

4.10.1.2 Interview guide and questionnaire

The HVS interview questions are customized for supply stakeholders. For example, questions for the Welsh Government and local authority are different to the commercial suppliers, particularly regarding shared financial capital (e.g. grant funding versus private investment). In addition, demand HVS questions for LDCs, rural MBs and residents have been incorporated into the Rural Social Capital Assessment Tool (RSCAT) to reduce the time required to interact with the local community. CSO interviews are conducted separately after they have been identified by the rural community. The HVS exogenous supplier questionnaire can be found in (Appendix I).

4.10.2 Divergence – HVS change record (1)

As stated, changes to the original research design considers findings from the Taskforce (September 2019) and from initial interviews with demand stakeholders (January 2020). Details of the core findings will be explained in (Chapter Five), but in summary, a new initiative has taken place in Wales. The Pembrokeshire County Council (PCC) has employed two digital Engagement Officers (EO) which acts as a "top down" intervention versus the "bottom-up partnership" intervention originally planned in the conceptual framework (Section 3.8.8). The introduction of the EOs into

the case study area changed the focus of the HVS interviews for the demand stakeholders. The rural community will no longer have to organise themselves or engage the community on a volunteer basis. Instead the local authority is providing that role for the community.

4.10.2.1 Changes to HVS endogenous demand questionnaire

The HVS demand questionnaire, embedded in the RSCAT (Appendix I) was updated as a result of these changes to include pre- and post-EOs questions and the removal of questions directed at assessing whether or not the rural community was aware of the various community-led funding initiatives available to them. Moreover, a finding from a Welsh Government representative (during a Taskforce meeting), explained a marketing survey has been commissioned to interview the remaining 95k white premises, and part of that questionnaire is to discover if rural communities are aware of the various funding streams, or not. In order not to duplicate work, the RSCAT was adjusted to account for these interventions.

4.10.3 Rural Social Capital Assessment Tool (RSCAT)

The purpose of the RSCAT is to assess the rural capital assets within a *place-based* community, but with a primary focus on the cognitive and structural social capital embedded in the rural community which can play a critical role in the success or failure of investment.

The RSCAT is an adaptation of the World Bank SCAT, the Community Capital Framework (CCF), and the OECD Social Capital databank. The CCF identified seven rural capitals as assets embedded within every rural community (e.g. built capital, cultural capital, financial capital, human capital, political capital, natural capital and social capital) (Section 2.3.3). Not all rural capitals will be assessed to maintain the scope of this research (e.g. cultural & political capital are excluded).

The World Bank spent years developing, piloting and field-testing SCAT to assess communities designated as investment beneficiaries for development projects (World Bank, 1999). In addition, the OECD summarised 1200 social capital survey instruments (OECD, n.d.) to assess country-level statistics. The following sections breakdown each instrument and the reason why it will be incorporated.

4.10.3.1 Background of the World Bank Social Capital Assessment Tool (SCAT)

The SCAT organises social capital measurements on a macro-level (e.g. impact of political institutions & the rule of law) and micro-level (e.g. rural communities). The macro-level analysis, although relevant, is outside the scope of this thesis. The unit of analysis for this inquiry is the community-level. The micro-level however assesses two relevant constructs relevant to this thesis: structural and cognitive social capital. The SCAT assesses the tangible *structural level* (e.g. compositions & practices of local level institutions both formal & informal that serve as instruments of community development), and the less tangible *cognitive social capital* (e.g. values, beliefs, attitudes, behaviour & social norms of a community). The World Bank defines values to include trust, solidarity and reciprocity that are shared among members of a community and that create conditions under which communities can work together for the common good (Woolcock & Narayan, 2000).

The World Bank uses Putnam's (1995) Italian municipality study definition of social capital *"features of social organisations, such as networks, norms and social trust that facilitate coordination and cooperation for mutual benefits" (p. 67).* **Mutual benefit** is a key concept in this thesis.

To restate, the aim of SCAT is to investigate the non-financial value of social capital within a community designated as investment beneficiaries for development, hence this definition supports the social capital definition used for this thesis.

4.10.3.2 World Bank SCAT methodology

The World Bank organises their assessment into community, household and organisational characteristics and the structural and cognitive social capital therein. The World Bank categories of inquiry to evaluate a developing nation overall community asset are beyond the scope of this inquiry and not relevant to this topic of rural NGA services. For example, the World Bank assesses drinking water, electricity, garbage collection, public lighting, public markets, recreation, security, sewage and transportation. Nonetheless, they assess home communication and telephone services which are relevant to this inquiry.

The SCAT consists of five sections, but not all will be used or adapted for this thesis (World Bank, 1999):

1A. Community Profile and Asset Mapping – Interview Guide (will be used).

1B. Community Questionnaire – modified to digital capital assets (will be used).

1C. Household Questionnaire – (will not be used).

1D. Organisational Profile – Interview Guide – outside of scope (will not be used).

1E. Organisational Profile – Scoresheet – outside of scope (will not be used).

In addition, the World Bank sends teams of researchers to work with focus groups to paint as complete data set as possible for analysis. This researcher neither has the resources or the time to do such an in-depth analysis, nor is the entire SCAT profile relevant for this study.

The adaptation of the SCAT therefore will consist of community profile and asset mapping, community questionnaire to determine structural and cognitive social capital, but the detailed household and organisation profiles to determine memberships and networks of individual and political groups are considered outside the scope of this inquiry. Semi-structured interviews with 3-6 community members and organisations is enough to map the community assets (e.g. World Bank identified 3-6 organisations as sufficient) (World Bank, 1999).

4.10.3.3 Adaptation of World Bank SCAT for this thesis

The micro-level rural community is the unit of analysis (Section 4.4.1). Both structural and cognitive social capital will need to be assessed, because trust, networks, and institutional support are factors for supply and demand implementation.

To construct the instruments, it is critical to identify the broad analytical categories relating to the dimensions of rural and social capital. Operationalising emerging theories regarding dimensions of rural and social capital include clarifying the units of analysis and the variables of interest. Hence, a summary review of definitions is required to ensure clarity of the variables to be assessed.

The modified interview guide is from the SCAT instrument methodology. The purpose of the social capital assessment tool is to map the rural community and identify the positive and negative ICT assets. The aim is to identify community leaders,

organisations, how decisions are made and establish a baseline understanding of trust, social cohesion and the capacity (or lack thereof) for collective action.

A final point in the Maua mutual business methodology defines a "*value ecosystem"* by identifying CSOs within the community who have a significant amount of human & social capital within the community (Section 2.2.4). The aim is to identify the "non-financial" assets to work alongside financial capital for the success of getting a product to final few markets (Section 4.4.4).

4.10.3.4 Flora (2016) Community Capital Framework (CCF) – Rural capitals

Rural capital was identified in the context (Section 2.2.3) and the literature review (Section 3.6.7). Henceforth, they are included in the rural community instrument design. The goal of the CCF is to activate and develop rural capital assets into a *"healthy ecosystem – vibrant regional economy and healthy happy communities"* (Section 2.2.3, Figure 2.4). The seven CCF rural capitals as *assets* were defined in (Section 2.2.3) but cultural and political capital are considered out of scope for this inquiry. The rural broadband definitions as *assets* are defined in (Sections 3.6.7) and summarised in (Appendix N).

4.10.3.5 Pilot testing

The instruments were pilot tested through a debrief panel to ensure the continuity and relevance of questions (December 2019). The HVS and RSCAT endogenous demand instrument were timed to ensure questions can be answered within a reasonable time frame. The debrief panel included the researchers internal Supervisors who provided advice, coaching and feedback for question construction. Adjustments were made as a result of feedback from the debrief panel and pilot participants. Pilot participants included a couple who recently moved to a deep rural Wales location (mid-Wales) and an internal Supervisor who lives in a rural community (South Wales).

4.10.4 Divergence – RSCAT change record (2)

During interviews with demand stakeholders (January 2020), it became evident that the SCAT was not fit for purpose with a small rural hamlet of 20 properties. The outcome of interviews with the LDCs in both SV-A and B (January 2020) highlighted that social capital is indeed present, but it exists *informally* rather than *formally* as the

World Bank analyses. Hence, the original RSCAT instrument was greatly modified to reflect its utility. The updated version can be found in (Appendix I).

In addition, the CCF (Section 2.2.3) was originally planned to capture the various capital assets within the community. Due to time constraints the original assessment will be made part of future recommendations (Appendix N). In summary, the revised HVS and RSCAT endogenous demand questionnaire can be found in (Appendix I).

4.10.5 Summary of Instruments

In summary, the originally intended research design based on the conceptual framework (Section 3.8.8) has been adjusted as a result of the divergence changes: namely adjustments to the HVS demand questionnaire, reduction of the original RSCAT and removal of the CCF. The modified demand HVS and RSCAT questionnaires can be found in the (Appendix I). A summary of the revised RQs and originally intended methods is provided (Table 4.5).

Table 4.5 Summary of revised RQs and methods used for exploration

Research Questions (RQ)	***Methods to answer RQs***
RQ1. What capital resources are required to support infrastructure to enable NGA to be viable for rural communities & MBs to experience four-fold capital benefits?	Hybrid Value System (HVS) – exogenous & endogenous qualitative semi-structured interviews. Rural Social Capital Assessment Tool (RSCAT) – local rural community (based on World Bank Social Capital Tool).
RQ2. How can multiple stakeholders in both supply & demand ecosystems mutually learn & cooperate to resolve this complex rural digital divide challenge?	HVS methodology. RSCAT methodology.
RQ3. What new innovative approaches can be utilised to manage & measure this process?	Mutual business methods – HVS, RSCAT, mutual learning & cooperative interplay. Reflection on the eight-stage model - neo-endogenous (NED) synthesis opportunities.

4.11 Academic rigour - Data analysis methods

Stake (1995) states that *"the case is complex, and the time we have for examining its complexity is short"* (p.76). This statement is true of this research. Stake (1995) argues there is a trade-off between naturalistic generalisations describing the intrinsic case study versus the time taken to generalise results. The author argues researchers need to make important strategic choices to organise analysis and interpretations to accommodate both outcomes (p. 86). Hence, the interactivity of the research design was required to accommodate the divergence records (Maxwell, 2012). The data collection techniques were detailed in field procedures (Section 4.7.2). Observation and transcript data was collated, managed, organized and visualised through NVivo12 Pro and coupled with traditional manual methods for a more intimate engagement with the data (Maher, Hadfield, Hutchings, & de Eyto, 2018).

Thematic analysis (for coding & trustworthiness) and thematic network analysis (for mapping & analysis) was used to analyse the data (Attride-Stirling, 2001; Nowell, Norris, White, & Moules, 2017). Memo-writing and reflection diaries have been kept throughout this process, to ensure rigorous methodology, clarity and transparency of the process (Bansal et al., 2018; Cassell et al., 2018). One of the arguments against qualitative research is the subjective nature, but rigorous methodologies can overcome these concerns (Bazeley, 2009).

4.11.1 Thematic analysis (TA) & thematic network analysis (TNA)

When setting out to analyse qualitative data, there are a range of established qualitative data analysis tools and techniques to choose from such as content, discourse, hermeneutic, narrative and thematic analysis (Alhojailan, 2012). Thematic analysis (TA) was selected for this study because of its flexibility and not being aligned to any one philosophical approach (Alhojailan, 2012; Braun & Clarke, 2019; King & Brooks, 2018; Nowell et al., 2017). This is further justified, because discourse and hermeneutic analysis involves identifying gender, language or power analysis which is not the focus of this thesis. Equally, content and narrative analysis are not suitable because of their focus on communication versus the identification of themes and patterns arising from the text. It is the identification of the themes and patterns in the responses that make TA so advantageous, because this study aims to identify core assets of several stakeholders and the critical success factors from the data provided.

Furthermore, King and Brooks (2018) explains that TA provides flexibility, strategies and structure for the researcher to see the "wood through the trees" (p. 16). Alhojailan (2012) suggests, as opposed to grounded theory or hermeneutic analysis as theoretically prescribed methods, TA allows flexibility to start analysis at any point during the project and can use both inductive and deductive analysis.

There are numerous styles of TA. King and Brooks (2018) detail four generic styles, apart from methodology specific styles (e.g. grounded theory or interpretive phenomenology). The four generic styles are not tied to any one method, philosophy or theory. The generic styles are Framework Analysis, Matrix Analysis, Template Analysis and Braun & Clarke's version of TA. The first three methods make use of code books (e.g. *a priori* coding) deductive approach, while Braun & Clarke take a bottom-up inductive approach. Fereday and Muir-Cochrane (2006) extend the inductive/deductive thematic analysis by incorporating a *hybrid-approach* to incorporate induction (e.g. themes emerging from interviews) and deductive approaches (e.g. derived from philosophical framework) (p. 91). This hybrid approach will be used for data analysis because of the *a priori* capital definitions and pragmatic worldview required to define the boundaries and scope of the data (Section 3.6.7).

King and Brooks (2018) note all TA styles can be simplified and summarised into two core processes: defining themes and organising them into some form of structure that captures the relationships between them (p. 7). Additionally, TA constitutes three main areas to manage the volume of qualitative data collection. These broad themes are broken down into data reduction, data display, and conclusion drawing and verification (Alhojailan, 2012; Miles & Huberman, 1994). For this thesis, a hybrid TA approach is used to reduce the text, and then incorporated into *thematic networks* to organise and visualise the data.

Thematic network analysis (TNA) is a supplementary qualitative data analysis tool. This is considered beneficial to this study because the HVS ecosystem (e.g. identifying & connecting the core assets of several stakeholders) within and across both exogenous supply and endogenous demand ecosystems can be considered a form of "network" analysis (Section 3.8.8). Thus, TNA can aid in managing the complexity of the data involved in this research when analysing the four-fold capitals of multiple stakeholders across two ecosystems.

Attride-Stirling (2001) define thematic networks as *"web-like illustrations that summarise the main themes constituting a piece of text"* (p.385) and are a useful tool for organising, analysing and presenting network data. TNA organise the data extraction into three themes: basic themes (e.g. lowest-order premises in the text), organising themes (e.g. categories of basic themes grouped together to summarise more abstract principles), and global themes (e.g. super-ordinate themes encapsulating the principal metaphors in the text as a whole) (p. 388). Notably, thematic networks is only a data organising and visualisation technique, it does not provide discussion or analysis. Additional techniques will be employed for discussion and analysis (e.g. social network analysis tools) (Bazeley, 2013). A process summary of TNA is presented in the following (Table 4.6).

Table 4.6 Process summary for devising thematic networks (Attride-Stirling, 2001, p. 391).

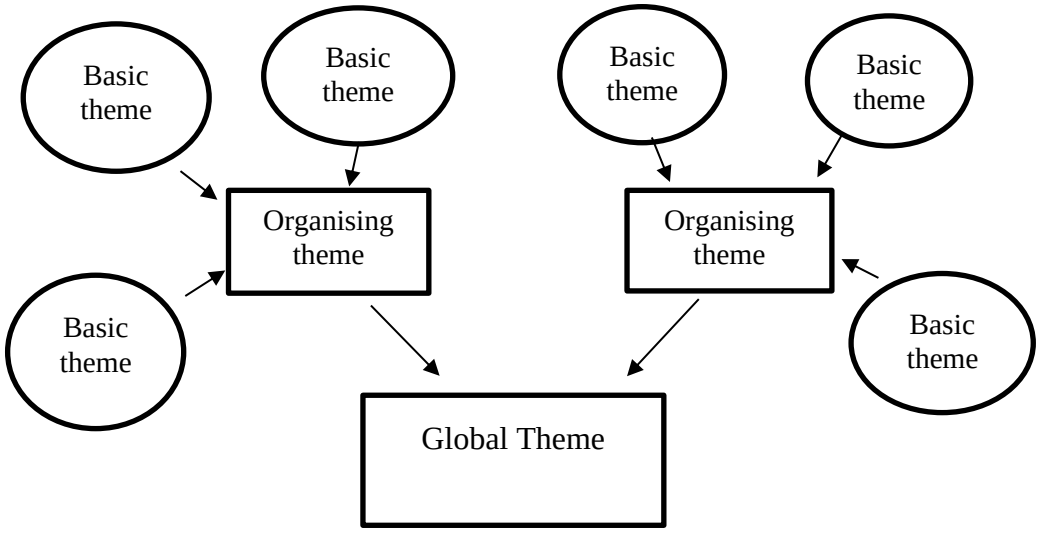
Analysis Stage A – reduction or breakdown of text		
Step 1	Code material	a. Devise a coding framework b. Dissect text into text segments using the coding framework
Step 2	Identify themes	a. Abstract themes from coded text segments b. Refine themes
Step 3	Construct thematic networks	a. Arrange themes b. Select basic themes c. Rearrange into organizing themes d. Deduce global themes e. Illustrate as thematic networks f. Verify & refine the networks
Analysis Stage B – exploration of the text		
Step 4	Describe & explore thematic networks	a. Describe the network b. Explore the network
Step 5	Summarise thematic networks	
Analysis Stage C – integration or exploration		
Step 6	Interpret patterns	

Attride-Stirling (2001) notes some central considerations when working through the steps similar to the generic styles explained above. For example, when coding the material (Step 1) there is potential to use pre-establish criteria (e.g. *a priori* code book). The author suggests setting definitive boundaries and definitions to limit the scope and explicitly focus on the object of analysis. When identifying themes (Step 2) it requires close interpretive attention to conceptual detail. Once all the text has been coded,

themes are abstracted from the coded text segments. It is a painstaking step but necessary to ensure each theme is specific enough to capture relevance of one idea, but broad enough to incorporate others. Following the construction of the networks (Step 3) the global theme is identified as the *core principal metaphor*. Each global theme will produce a thematic network. Once the networks have been established, describing, and exploring the network (Step 4) is the beginning of analysis. It is essential for the researcher at this stage to return to the original text and interpret the data with the aid of the thematic network. The author suggests using a sequential order (e.g. clockwise), so there is a logical flow and presentation for the researcher and the reader. Summarising (Step 5) and interpreting patterns (Step 6) aims to present the findings "succinctly & explicitly" in relevance to the RQs and theoretical constructs identified in the literature review (Section 3.9).

Analysing qualitative data, particularly within networks and relationships can be complex. The core purpose of using TNA as an organisational and visualisation tool is because the web-like nets emphasise the *"interconnectivity throughout the network*" (p. 389). A summary of the TNA structure is presented in (Figure 4.5)

Figure 4.5 Example of thematic network analysis (TNA) structure (Attride-Stirling, 2001, p. 388)



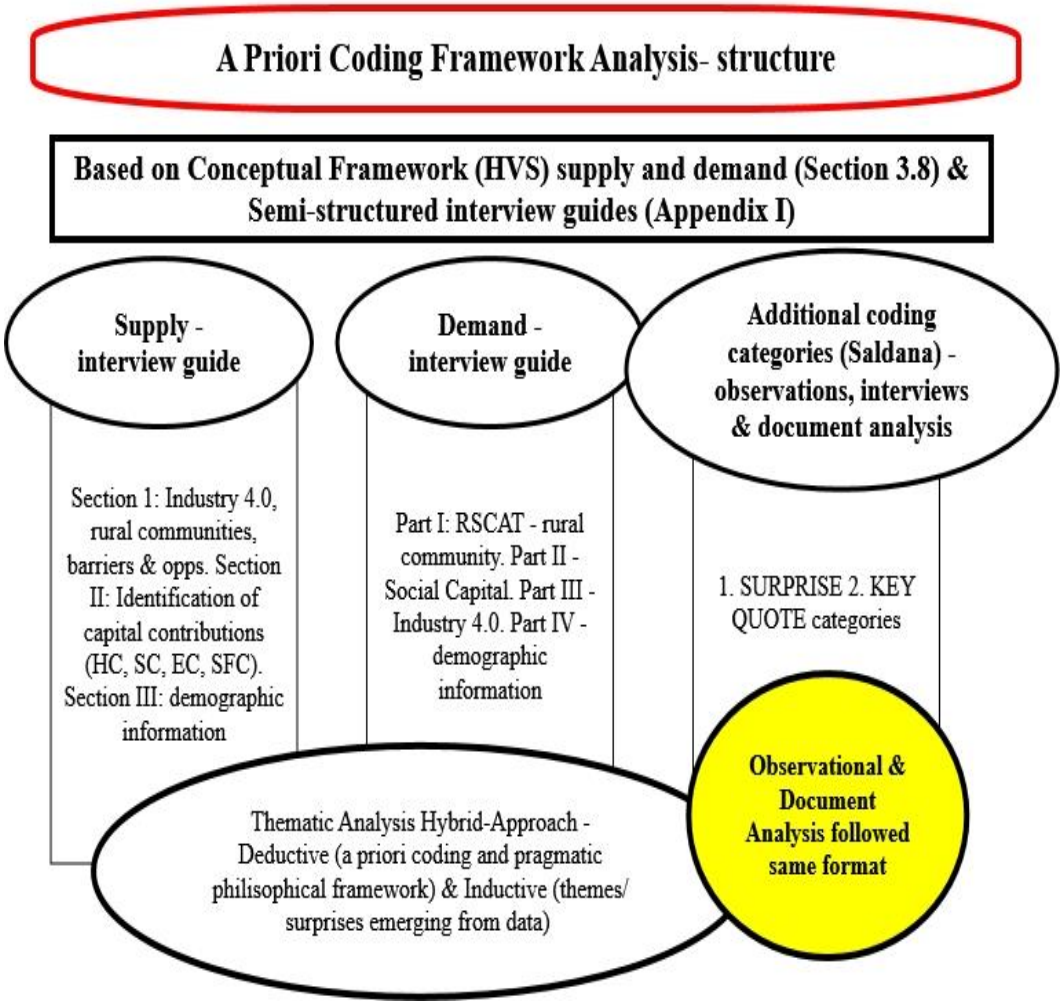
In summary, the interconnected ecosystems and subsequent networks are a primary focus of this research. Hence, these analysis tools are the most relevant for this methodology.

4.11.2 Coding framework & *a priori* codebook – TA hybrid-approach

The coding framework was constructed from the conceptual framework (Section 3.8.8) and the semi-structured interview guides (Section 4.10 & Appendix I). For example, the conceptual framework incorporates the "themes" of the supply and demand ecosystems four-fold capitals, drivers, opportunities, barriers and so forth (Section 3.8). Furthermore, the framework acted as an aide memoire for organising and coding the observation, interview and secondary (Tier Two & Three) document analysis (Section 4.8.2 – 4.8.6).

The coding framework will be used as an overall structure to start coding in NVivo the answers to the questions in the semi-structured supply and demand interview guides. For example, the structure for the supply interview guide is set in three sections and the demand interview guide in four parts (Figure 4.6). Saldana (2015) suggested adding categories to capture "surprises" and "key quotes" which will be used in the initial first cycle coding. A thematic analysis hybrid-approach for both deductive (*a priori*) and inductive (emergent & surprise) coding will be used (Section 4.11.1).

Figure 4.6 The Coding Framework - Aide memoire



The *a priori* codebook is designed to capture the four-fold capitals and is based on the operational definitions identified in the literature review (Section 3.6.7). For example, human capital is defined as a unique set of skills, attributes and knowledge of an individual that contributes to productivity (Schultz, 1961). Therefore, the human capital coding reflects the skills, knowledge, and personal attributes. Social capital was defined as the trust, belief, norms, rules, and networks that constitute the value of relationships for collective action (McElroy et al., 2016). Thus, the social capital coding reflects trust, relationships, and networks. Moreover, organizational trust was defined as the ability to accomplish a goal and "get the job done" (Section 3.6.6.1) to reach the final few (pragmatic/practical output). The following table captures the *a priori* coding and definitions (Table 4.7). Definitions are taken from Cambridge online dictionary (Appendix K).

Table 4.7 Summary of *a priori* codebook

Parent Codes	Codes	Definition	Central Questions
Human Capital	*Skills*	A particular *ability* that you develop through training & experience & that is useful in a job.	What skills do you need & value to get the job done?
	Knowledge	Skill in, understanding of, or *information about* something, which a person gets by experience or study: Explicit & implicit (tacit).	What knowledge do you need & value to get the job done?
	Personal attributes	A *quality* or characteristic that someone or something has.	What personal attributes do you need & value to get the job done?
Social Capital	*Trust*	(Section 3.6.4) – *ability to act*; to accomplish it (e.g., trust them to act in mutual best interests); "get the job done" to reach the final few.	Is trust important to get the job done?
	Relationship	The way in which two or more companies or people *behave* towards each other.	How important are relationships to get the job done?
	Network	A group of people or organizations in different places who *work together and share information.*	How important is working together & sharing information to get the job done?

**Please note – the converse questions were asked as to what hinders or obstructs skills, knowledge and so forth to get the job done.*

In brief, environmental capital (EC) and shared financial capital (SFC) did not require *a priori* coding. EC asked questions relating to video conferencing and working from home to reduce carbon footprints. SFC revolves around funding models such as state aid and private finance, so explicit coding was not required for these two capitals. The operational definitions for human & social capital however are foundational to the coding framework and explained further in (Appendix J & K).

4.11.3 Coding process, operational definitions & data displays

The coding process follows Miles and Huberman (1994) data reduction, analysis and display techniques, and Saldana (2015) first, second and third coding cycles for case study analysis. For example, first cycle methods can include: Attribute (demographic), Descriptive (context), Holistic or Structural (for general overview) and In Vivo or Initial coding (attune to participant language, perspectives, worldviews). Second cycle

can include Pattern or Focused coding (for categorisation of coded data) which will aid thematic network analysis (TNA) for visualising and organising the data. Saldana (2015) refers to a mix of coding strategies as a "pragmatic eclectic method" which would support the philosophy and complexity of this thesis. Details of the operational definitions and data displays (e.g. coding results & quotation maps) will be explained in (Chapter Five, Six & Appendix J).

Data analysis was conducted during COVID19 outbreak (April-June 2020). NVivo 12 was used for the analysis during a period when large-scale printing that would be required for manual coding was not available. Detailed coding method and process checklists can be found in (Appendix J & K). However, a summarised data analysis process followed these general steps:

Data Reduction

1. Coding Framework – initial coding structure - TA hybrid-approach (Figure 4.6)
2. A Priori Codebook - first, second & third cycles (Table 4.7).
3. Thematic Network Analysis (TNA) – A3 paper copies to map & organise results.

Data Analysis

4. Analytical memos per interviewee – reflective questions (Table 4.8).
5. Focus on most salient & meaningful data to answer RQs (time constraint).
6. Operational definitions – critical analysis to manage complexity (TNA).

Data Display

7. Code Maps – using NVivo mind maps (salient codes & TNA to answer RQs).
8. Quotation Maps – using NVivo software (data display to answer RQs).

In summary, a timetable on how the approach and methods for data analysis (e.g. observations, interviews & documents) is summarised in (Section 4.12.1, Table 4.9).

4.11.4 Reflection - Analytical memos & most meaningful data

Saldana (2015) suggested using analytical memos for reflection. The purpose is to reflect on coding process and choices, how the process of inquiry is taking shape and identifying emergent patterns, categories, themes and concepts (p. 50). The author suggests reflecting and writing on (Table 4.8):

Table 4.8 Analytical memos – reflection analysis

Memo	Question
1	How the researcher relates personally to the participant or phenomenon
2	About the study's research questions
3	The researchers code choices & operational definitions
4	Emergent patterns, categories, themes, concepts & assertions
5	Possible networks – links, overlaps, flows – among codes, patterns, categories, themes, concepts & assertions = code weaving.
6	Emergent or existing related theory
7	Any personal or ethical dilemmas
8	Problems with study
9	Future directions of study
10	The analytical memos thus far
11	Final report of the study

Furthermore, Miles & Huberman (1994) suggest focusing on the most salient codes and data to avoid data overload and prioritise the most meaningful data (p. 53). The most meaningful data in this instance will be unexpected surprises and answers to the RQs.

In summary, to manage the complexity and volume of the multiple data sources, across two ecosystems and reduce researcher subjectivity and bias, this study aims to employ these qualitative best practices for analysis. The analytical memos provide an organised method and consistent process on how to analyse and draw meaning across the multiple data sets. Thus, these reflective questions and suggestions will be utilised when processing the data to answer the RQs.

4.12 Reliability, reflection, validity & trustworthiness

The question of reliability and validity are similar yet different for qualitative and quantitative data analysis (Bryman & Bell, 2015). Qualitative data reliability and validity have a different language to quantitative. Quantitative researchers criticize qualitative researchers on the robustness of the reliability and validity in comparison to quantitative techniques (Mays & Pope, 1995). Thus, a case study protocol is used to combat these concerns and ensure academic robustness (Section 4.7).

Qualitative reliability and validity can reside in audit trails (e.g. meticulous documentation), member checks, peer review of data, pilot testing the interview, triangulation and so forth) (Collis & Hussey, 2014). Bryman and Bell (2015) cite from Lincoln & Guba's 1985 work who propose authenticity and trustworthiness as a language to combat the objectivist/quantitative critiques. Trustworthiness is made up of four criteria, as a juxtaposition to quantitative language for reliability and validity. For example, credibility for internal validity, transferability for external validity, dependability for reliability, and confirmability for objectivity. Credibility is described as respondent validity and triangulation. Transferability as a rich description. Dependability with complete and detailed records through all phases of research (e.g. case study protocols). Confirmability is shown to have acted in good faith. For this research, a case study protocol, to detail every stage of the research will be employed to ensure data is transparent and shown to be reliable and valid (p. 400) (Appendix G).

King and Brooks (2018) suggest the approach to qualitative data quality assurance is contingent upon the philosophical roots of the study. The authors list three strategies adapted from philosophical roots: audit trails (e.g. noting changes to themes using annotations, cross-referencing, reflexive analysis & research diary), inter-coder comparison (different realist & relativist approaches) and participant feedback (or member checks) (p.5). The role of this researcher (Section 4.3.2 & 4.3.3) recognises the incorporation of researcher reflectivity and reflexivity as becoming an integral part of qualitative business research methods (Cassell et al., 2018). Thus, a reflective diary was used to capture the researcher's experience throughout this process. A researcher reflexivity examination is detailed in (Appendix O).

Furthermore, Nowell et al. (2017) provide useful guidelines and criteria to aid qualitative research trustworthiness and validity. The authors list audit trails, confirmability, credibility, dependability, transferability and reflectivity as central to audit trails. Nowell et al. (2017) provide a helpful summary of each phase of their thematic analysis (using Braun & Clarke version) with the corresponding actions to ensure trustworthiness of the data and transparency of the process. This method is beneficial for providing a clear step-by-step guide for this thesis. The authors capture each of these validity criteria alongside the phases of thematic analysis. This guide will be used as a checklist during analysis (Appendix J.2, Table J.2). Moreover, this researcher created a "how I validated my research" checklist (Appendix J.1, Table J.1) when reflecting on best practice identified in the methodology throughout chapter four.

In summary, every effort is made to ensure reliability, reflection, trustworthiness and validity of the data. The use of case study protocol as a template and checklist is updated in (Appendices G & H). How this researcher validated the work (Appendix J.1). The use of the thematic analysis checklist (Appendix J.2) and an overall detailed step-by-step process for data analysis is summarised in (Appendix J.3).

4.12.1 Summary of multi-method data analysis & time frame

The operational definitions for human & social capital are fundamental to the analysis because they define the *a priori* coding parameters for human capital (productivity) and social capital (collective action). As discussed in the ontological and epistemological approach, and the pragmatic nature of the research, the study involved a multi-method approach (Section 4.2). The pragmatic philosophical lens to "get the job done" will act as an aide memoire when coding the most meaningful and salient data to answer the RQs. The pragmatic lens and code framework provides focus and scope to the complexity and volume of data (Section 4.2.1). The TA hybrid-approach for deductive (a priori) and inductive (salient points/emergent patterns/surprises) will aid in coding and managing the complexity of both ecosystems (Section 4.11.1 – 4).

The results of TA, TNA and data displays are throughout (Chapters Five & Six). Data collection methods and timeframes, particularly for key stakeholder interviews, were summarised in (Section 4.8 & Figure 4.4). The multi-method data analysis timeframe and schedule is summarised in the following (Table 4.9) and detailed in the overall data analysis process (Appendix J, Table J.3).

Table 4.9 Multi-method data analysis – timeframe summary

Date	Data	Approach/Method	Section
2019 - 2020	**Philosophical lens** – for data analysis and focusing on how to "get the job done".	Pragmatic limited realist approach – develop an account that is credible & potentially transferable, while recognising conclusions will always be tentative.	Pragmatism – (4.3.1, Table 4.1).
		Often use *a priori* themes informed by theory.	Human capital (3.6.5) & Social capital (3.6.6).
		Quality checks to stimulate critical thinking, specific to needs of particular study.	Researcher checklists (Appendix J.1). Thematic analysis & thematic network analysis (4.11 & Appendix J.2 checklist).
		Reflection in analysis is important to go beyond researcher subjectivity.	Analytical memos (4.11.4, Table 4.7) & Appendix J.1 – J.3
May & June 2019	Observation data: **Conferences** (n=3) (Section 4.8.4/Procedure IV).	Used code framework as an aide memoire (e.g. coding surprises & key quotes to answer RQs - Industry 4.0, four-fold capitals, barriers, opportunities).	Code framework (4.11.2, Figure 4.6). *A priori* coding (4.11.3, Table 4.6).
September 2019 – March 2020	Observation data: **Taskforce meetings** (Section 4.8.4/Procedure IV).	Used code framework as an aide memoire (e.g. coding surprises & key quotes to answer RQs - Industry 4.0, four-fold capitals, barriers, opportunities).	Code framework (4.11.2, Figure 4.6). *A priori* coding (4.11.3, Table 4.6).
January 2020	Observation data: **Welsh Government Event** (Section 4.8.4/Procedure IV).	Used code framework as an aide memoire (e.g. coding surprises & key quotes to answer RQs - Industry 4.0, four-fold capitals, barriers, opportunities).	Code framework (4.11.2, Figure 4.6). *A priori* coding (4.11.3, Table 4.6).

September – March 2020	**Document Analysis** (Section 4.8.2/Procedure II Tier Three).	Code framework as aide memoire – to explain technical details, identify four-fold capitals, Industry 4.0. Coding surprises & most meaningful data to answer RQs.	Code framework (4.11.2, Figure 4.6). *A priori* coding (4.11.3, Table 4.6).
February – March 2020	**Interview transcription** (Section 4.8.5 & 4.8.6/Procedure V & VI).	Trint software used for initial transcription, followed by manual editing because Trint contains errors. Once completed, interview transcripts were uploaded to NVivo to start coding.	4.7.2 (Field procedures)
April 2020	**HVS key stakeholder interviews – Data reduction – initial set-up**	Supply (n=14) & demand (n=5) interview transcripts are separated under individual headings because Code framework for supply & demand have different structures based on semi-structured interview guides.	Code framework (4.11.2, Figure 4.6). *A priori* coding (4.11.3, Table 4.6).
April 2020	**Interview – Data reduction - coding process**	Each transcript coded individually using TA-hybrid approach – deductive (*a priori* coding) & inductive coding (capturing surprises, key quotes, most meaningful data). Using case study coding (e.g. In Vivo, Descriptive & so forth).	Code framework & *a priori* coding (4.11.2, Figure 4.6 & 4.11.3, Table 4.6). Analytical Memos (4.11.4, Table 4.7). Appendix J.3
April 2020	**Interview – Data reduction**	Data reduction process to produce first, second & third cycle coding to identify & clarify themes & categories.	4.11.1 – 3 & Appendix J.3.
April 2020	**Interview – Data analysis**	Code frequency – used to identify most meaningful responses to RQs.	4.11.1 – 3 & Appendix J.3.
May 2020	**Interview – Data analysis**	Reflection memos were constructed, & most meaningful data captured.	4.11.4 & Appendix J.3
May 2020	**Interview - Data analysis - organisation**	Organising themes using TNA framework – global, organising & basic themes – for deductive & inductive findings.	4.11.1 – 3 & Appendix J.3

May 2020	**Interview – Data analysis – theme organisation**	Using TNA to for more detailed analysis. For example: 1. Deductive - HC – skills, knowledge, personal attributes & SC - trust, relationships, networks. 2. Inductive – emergent & most meaningful data to answer RQs.	4.11.1 – 4.11.3 & Appendix J.3
May 2020	**Defining & naming themes**	TNA analysis – using operational definitions to clarify themes & most salient findings to answer RQs.	4.11.1 – 4.11.3 & Appendix J.3
June 2020	**Data Display**	Creation of numerous Quotation Maps (to primarily reflect In Vivo codes to remove bias) & Coding Maps (to summarise & present results of coding).	Chapters Five & Six
June 2020	**Producing the report**	Used the guide to case study report as the organisational structure to present findings. Chapter Five (nation/macro) – detailing observation, interview & document most meaningful findings to answer RQs. Chapter Six (local/micro) – detailing themes identified in Chapter Five to answer RQs.	4.7.4 – Case study guide

In summary, data analysis occurred throughout data collection (September – March 2020 and post-interviews March – June 2020) utilising TA hybrid deduction/induction (or abduction), TNA and most meaningful data methods to answer RQs. Interviews with key stakeholders were the primary data required to answer RQs. Observations and document analysis are weighted as supplementary data to the interviews providing context to answer RQs. The overall detailed step-by-step data analysis is found in (Appendix J.3).

4.13 Conclusion of research methodology

This chapter explored the theoretical underpinning and practical applications of this complex ecosystem research, including the research philosophy and methodology selected for the study. The aim of this research is to discover the conditions that enable rural communities and MBs to access and exploit NGA services, particularly in relation to Industry 4.0. The methods outlined in this chapter seek to discover the financial and non-financial capital value-add required for supply and demand resolution.

The philosophical world view is pragmatism, but with a limited constructivist realist approach to thematic analysis (TA). Thematic network analysis (TNA) will be used to organise the deductive and inductive data. Pragmatism does not lean towards one philosophy over another but seeks to combine subjective and objective viewpoints to answer the RQs.

An exploratory multi-method approach using a typical case study has been identified. A multi-method approach is required to enact the mutual business methodologies of the HVS and RSCAT (Section 4.10.1 & 4.10.3). Divergence modifications were explained in (Sections 4.10). The removal of CCF (Appendix N) will be included in future research recommendations (Chapter Eight). The HVS qualitative measures are to identify individual stakeholder pain points and capital resources that contribute to answering (RQ1). The complex ecosystem multi-capital and multi-stakeholder engagement within HVS and RSCAT contributes to answering (RQ2 & 3).

The purpose of the mutual business method is to value people, planet and profit and not restrict management practices or performance metrics to financial or profit-only assessments (Section 3.7.1). It is the traditional “financial-only” business and organisational thinking (paradigm*)* that is thought to be currently blocking the system (Section 4.4). Hence, the need to confirm this supposition and discover new and innovative ways in which these challenges can be addressed to reach the final few (Section 3.9). Technical complexities, although primarily outside the scope of this research, have been noted and are summarised to highlight the challenges suppliers face when building full fibre networks (Section 5.10.2).

A unique but typical intrinsic case study provides the opportunity to analyse exogenous supply and endogenous demand opportunities and challenges within the single Splits-Ville case study (Section 4.7.1). The opportunities to focus on a single intrinsic case study with multiple aspects should contribute to rich data collection (Cassell et al., 2018). The results of the exploratory multi-method approach are presented in the nation-level (macro) contextual analysis (Chapter Five) and local-level (micro) thematic analysis (Chapters Six).

Chapter Five: Complex Ecosystems

5.1 Introduction & Chapter Overview

The previous chapter outlined the research design and methodology with a phased procedural approach (Section 4.8). Data collection timeframes are within the Rural Gigabit Connectivity (RGC) programme roll-out from June 2019 (introduction of the programme) to March 2020 (end of data collection). Nevertheless, the endogenous demand rural stakeholder interviews began in 2016, 2018/2019 and 2020, respectively.

5.1.1 Nation-level context & local-level analysis

The following chapters are divided into two sections according to the summary of observations and interview guide (Section 4.8.7). The first section reviews the nation-level (macro) contextual findings in reaching the final few in Wales (Chapter Five). The second section will present the local-level (micro) analysis of the in-depth case study (Chapter Six) to answer the RQs (Section 4.10.5, Table 4.5).

Chapter Five: Results of observations, interviews & document analysis

The following (Sections 5.2 - 5.10) are the nation-level summary findings according to the three spheres of data capture (Figure 5.1). The findings from the observations, interviews and document analysis are reviewed in relation to the RQs.

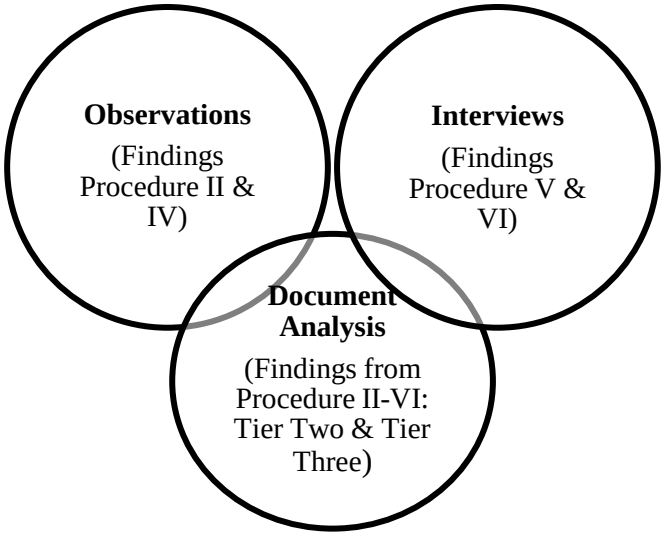
Chapter Six: Thematic analysis results & initial ecosystem-network analysis

The following (Chapter Six) describes the findings of the local-level thematic analysis which examines the evidence and themes identified in (Chapter Five) to answer the RQs. The findings of the initial network analysis are also presented in this chapter.

The data collection Procedures (I-VI) were identified (Section 4.8). The primary data collection occurred within parallel time frames (Section 4.8, Figure 4.3). This presented an opportunity as data from observations and initial interviews informed the data collection process, allowing focus as well as informing the researcher of the numerous sources of new grey literature for triangulation (Tier Two & Three). Data discovered from one source often influenced the questions asked in the others. The focus of the data collection was to investigate, through all three primary data sources, individual stakeholders' perspectives and capital contributions regarding NGA "full-

fibre & 5G" in a final few and hard to reach rural community in Pembrokeshire, South Wales. The findings are organised around the guide for the case study report (Section 4.7.4) and summarised according to the data collection methods in (Figure 5.1).

Figure 5.1 Summary of case study report guide (Section 4.7.4)



The following chapter therefore is organised according to these three interlocking spheres. The presentation of findings is not necessarily tied to a chronological timeframe but are interwoven as relevant findings are identified. Data analysis followed code framework and aide memoire (Section 4.11). The chapter overview is as follows:

Observation event findings - Procedure II & IV (Section 5.2)

As explained in Procedure II (Section 4.8.2) grey literature (Tier Two) document analysis (e.g. collected from conferences, events & meetings) was summarised in (Section 4.8.4, Table 4.2). The observation findings for this section are explained in (Section 5.2).

A summary of the Taskforce meetings was presented at the Welsh Government Broadband Funding Event (January 2020). The primary and surprise findings from these events are presented in (Section 5.2.1 & 5.2.2). This includes a recent proactive and innovative local authority approach to rural broadband engagement, specifically Pembrokeshire County Council (PCC) as a "First in Wales" initiative (Section 5.2.3).

Significant findings from conference data collection is presented in (Section 5.2.4) A summary of observation document data (Tier Two) is provided in (Section 5.2.5).

Exogenous supply interview findings - Procedure V (Section 5.3 – 5.6)

An overview of the exogenous supply participants in Wales is presented in (Section 5.3.1). Welsh Government interview findings are presented in (Section 5.4), including "First in Wales" initiatives such as the Taskforce (Section 5.4.1), PCC local authority (Section 5.4.2), Engagement Officers (EO) (Section 5.4.3) and Do it Yourself (DIY) options (Section 5.4.4). An overall summary of Welsh Government findings is provided in (Section 5.4.5). Interview findings for commercial supplier challenges are presented in (Section 5.5) and opportunities (Section 5.6). Overall exogenous supplier findings are summarised in (Section 5.6.8).

Endogenous demand interview findings - Procedure III & VI (Section 5.7 - 5.9)

Significant findings of rural MBs (2016) for Procedure III are summarised (Section 5.7.1) and demand investigation are presented in (Section 5.7.2). An overview of endogenous demand case study participants is provided (Section 5.8). Findings from Splits-Ville A (SV-A) interviews pre and post SFBB are presented in (Section 5.8.1 – 5.8.3). Rural Social Capital Assessment (RSCAT) findings are summarised in (Section 5.8.4). Findings from Splits-Ville B (SV-B) interviews pre and post EOs are presented in (Section 5.8.5). An unusual rural supplier "anomaly" was identified during the demand interviews and explained in (Section 5.8.6). Technical details to support this anomaly, although considered outside of scope, will be addressed to highlight the complexities of building full fibre networks (Section 5.10.2). Rural MBs and farmer interview results in (Section 5.8.7) and COVID19 findings (Section 5.8.8). An overall summary of significant endogenous demand findings is provided in (Section 5.8.9). A supply and demand interview summary regarding Industry 4.0 opportunities and barriers is explained in (Section 5.9).

Document Analysis (Tier Three) – findings from Procedure II-VI (Section 5.10)

Additional grey literature (Tier Three) collected from the interviewees (e.g. case study maps, commercial presentations & reports, environmental articles, 5G concerns, Facebook page, supplier quotations, Twitter feeds, websites & YouTube FTTH

network-build videos) will be summarised in (Section 5.10). Overall conclusions to the broad nation-level macro findings will be presented in (Section 5.11).

5.1.2 Data reduction, analysis & displays – Managing complexity

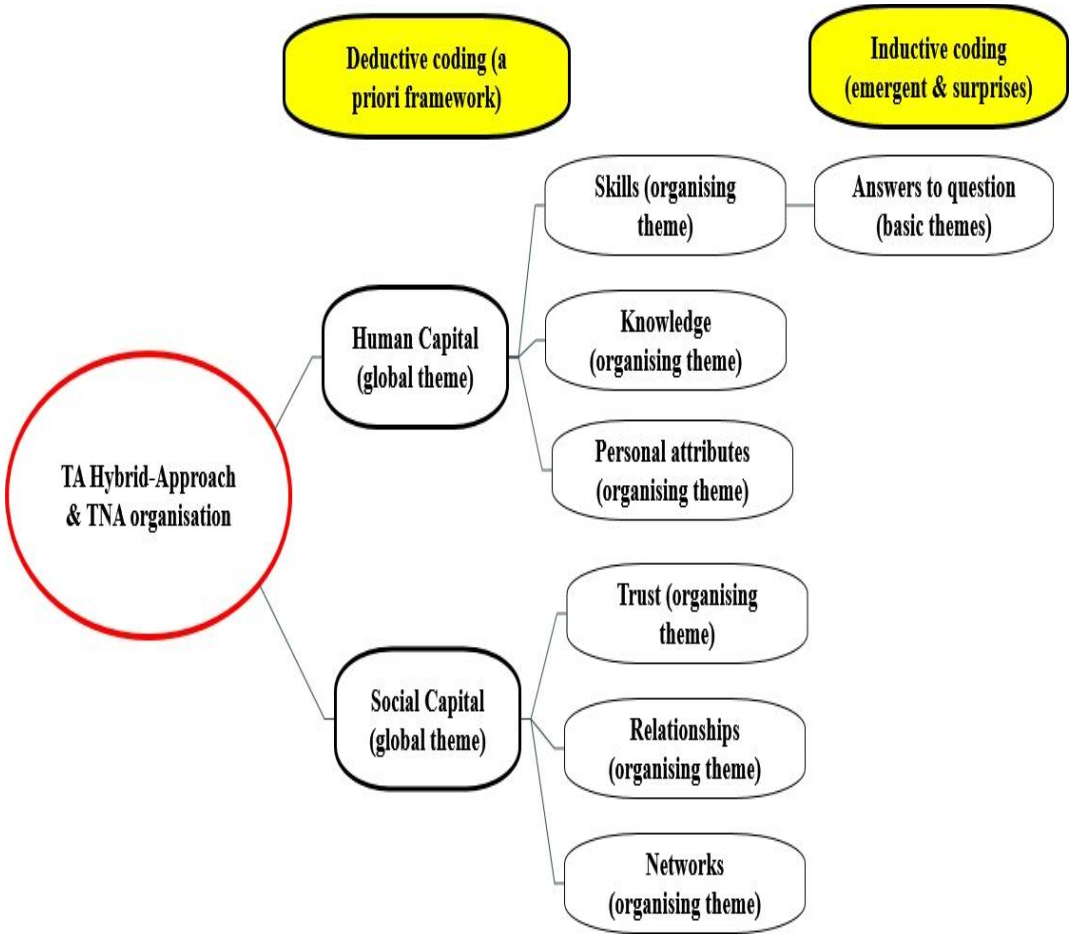
This research is complex due to the three sources of data (e.g. observations, interviews & documents) and the consideration of two ecosystems (supply & demand) alongside the investigation of four-fold capitals amongst a diverse and mixed group of stakeholders (Section 3.8). Moreover, all stakeholders were likely to hold a unique and different view on how to resolve the problem area (Section 4.1). To manage this complexity the Hybrid Value System (HVS) holds the neo-endogenous (NED) investigation, of both supply and demand ecosystems; in tandem, in order to explore the phenomena as holistically as possible given the limitations on time and resource.

The HVS aims to connect the core assets of several stakeholders, hence the focus on identifying those core assets in both ecosystems. The conceptual framework is the structure that holds the complexity to explore NED as separate identities (Chapter Five), detailed analysis (Chapter Six) and as an analytical whole (Chapter Seven).

Furthermore, the management of the three sources of data (Figure 5.1) and the subsequent reduction, analysis and display of all the data added to the complexity. However, by utilising the TA hybrid-approach (e.g. deductive a priori coding framework) first, followed by emergent themes and surprises (e.g. inductive coding) identified the core findings (Chapter Five). This approach coupled with the Thematic Network Analysis (TNA) to organise and map the data aided in managing the complexity (Section 4.11.1).

The TNA methods of identifying global, organising and basic themes is used extensively throughout this process and as an interchangeable tool for more detailed analysis (Appendix J.3). An example of the TA-hybrid and TNA structure for initial human & social capital coding, as primary focus of this thesis, is illustrated (Figure 5.2).

Figure 5.2 Data analysis – Example TA-Hybrid approach & TNA organisation



The TA Hybrid-approach and interactive TNA mapping process was helpful in organising the overall data (Chapter Five) and the detailed analysis (Chapter Six). The interactivity of TNA process allowed this researcher to employ a "Zoom In" (when breaking down & dissecting the text) and "Zoom Out" approach (when needing to re-organise the text into a bigger picture) to answer RQs (see Appendix J.3 for details).

In summary, Chapter Five (broad context/macro findings) will explore the complex ecosystems and identify the themes and critical success factors (CSFs) for detailed TNA local/micro analysis (Chapter Six) to answer the RQs.

5.1.3 Operational definitions

To understand the finesses to coding and organisation of the material, it is critical to reiterate the operational definitions identified in the literature review (Section 3.6.7) to code the transcripts. The primary focus for this thesis is a pragmatic exploration on how to "get the job done " (e.g. bring product to a final few market). Thus, the operational definitions reflect this primary aim.

To restate this critical imperative. Human capital is defined as: *"the unique set of skills, attributes and knowledge of an individual that contributes to* ***productivity****"* (Schultz, 1961). The social capital definition *"the trust, beliefs, norms, rules and networks that constitute the value of relationships for* ***collective action****"* (McElroy et al., 2016).

Hence, coding for human capital (hereafter referred to as HC) focuses on skills (e.g. ability), knowledge (e.g. understanding of, information about something), and personal attributes (e.g. individual qualities) to get the job done. Social capital (hereafter referred to as SC) focuses on trust (e.g. ability to trust them to do what), relationships (e.g. behaviour towards each other) and networks (e.g. working together & sharing information) required for collective action to get the job done. The definition for organisational trust is applied from (Section 3.6.6.1). Definitions are taken from the Cambridge University online dictionary, and where appropriate the business definition was used (Appendix K).

During second and third coding iterations, it became apparent to clarify the operational definitions and to distinguish personal attributes (individual qualities) from traits and behaviour. Attribute is defined as a *quality* or characteristic that someone or something has. Behaviour is defined as the way that someone or something *behaves* in a particular situation. Trait is defined as a particular characteristic that can produce a particular type of *behaviour*.

For example, is leadership a trait born to an individual or behaviour someone learns? In the context of this thesis, leadership is considered a productivity skill (ability) related to HC, although leadership can be defined as both a skill and a personal attribute (e.g. individual quality). Relationship is defined as the way in which two or more companies, countries, or people *behave* towards each other and is related to SC in the operational definitions. Henceforth, a distinction was made to differentiate HC (personal attributes & skills) as opposed to SC (behaviour or traits) for this reason.

Furthermore, SC identifies "beliefs, norms & rules" which may be implied but not specifically accounted for or coded due to time constraints and construction of the interview guides which focuses on trust, relationships, and networks for collective

action. A deeper analysis into individual or cultural beliefs, norms and rules can be added to future research (Chapter Eight).

Conversely, the barriers (e.g. something that *prevents* something else from happening or makes it more difficult: something that *keeps people or things apart*) or hindrances (e.g. something that makes it *more difficult for you to do something* or for something to develop) and obstacles (e.g. something that *blocks* you so that movement, *going forward*, or action is prevented or *made more difficult*) to HC productivity & SC collective action in getting the job done were identified. The terms barriers, hindrances and obstacles will be used interchangeably because preventing something or keeping people apart versus making something difficult or blocking movement have slight nuances that are relevant to this analysis. To put it more simply barriers can be viewed as "walls" while hindrances and obstacles can be viewed as something to "overcome" or give "hope" to overcome and get things done.

5.1.3.1 Data reduction

The observation, interview and document coding followed a pre-structured approach (Saldaña, 2015) (Section 4.11.2 & 4.12.1). For example, the context is Industry 4.0 and the final few and hard to reach rural communities. The capital resources required to answer RQ1 are participants responses to the four-fold capitals. Identifying mutual learning and cooperative interplay opportunities for complex ecosystems are related to RQ2. New innovative approaches identified in the data collection contribute to answering RQ3. Henceforth, the code framework and operational definitions are found in (Section 4.11.2 & Appendix K).

The data reduction process (Section 4.11.3) followed first cycle identification of Attribute (demographic/context), Descriptive (describes topic/surprises), Holistic ("chunk" data into topic area/general overview), In Vivo (verbatim participant response), Simultaneous (overlap/intersections), and Structural (*a priori* & code framework) coding for case studies (Saldaña, 2015). Second cycle coding included: Pattern (emergent, similar or repeated codes) and Focused coding (to answer RQs). Third cycle coding for clarification and refinement. Detailed coding process is found in (Appendix J.3).

5.1.3.2 Data analysis

Code frequency was reviewed after first cycle coding and determined not to be a primary tool for analysis because of the multiple stakeholder's viewpoints. For example, answers to Industry 4.0 could be grouped under "Context" or "Surprise" and answers to trust were individually specific. Thus, code frequency was not meaningful in these instances (Appendix J.3).

Code frequency for answers to HC & SC (Chapter Five) was meaningful and used to validate CSFs and reduce global and organising themes (e.g. leadership & proactive categories) (Chapter Six). For example, HC first cycle coding totalled (n=73) and eventually reduced to (n=43) (Appendix K.1). To illustrate how the code frequencies were used a breakdown of two global HC themes are explained:

- **Personal Attributes** (organising theme) identified award winning (n=3), generosity/inclusivity (n=2), non-confrontational (n=1), open-minded (n=1) and proactive **(n=10**), ambition **(n=7)**, dynamic (n=2), enthusiasm (3), tenacity (2), understanding (1). Highlighted frequency counts aided validation of inductive proactive theme (e.g. In Vivo code & triangulated theme through observations) (Chapter Five). Proactive operational definition (e.g. taking action) was then used as organising theme (Zoom In) to capture related codes such as ambition and then global theme for CSF (Zoom Out) (Chapter Six).
- **Skills** (organising theme) had the most codes (n=60) and had to be re-organised and re-coded in second/third cycle coding. For example, to breakdown skills, Soft Skills (re-categorised as an organising theme for analysis) identified champions (2), communication (**6**), community engagement (4), competing priorities (1), conflict resolution (**12**), inspiration (6), motivation (**15)**, problem solving (1), hate term 'soft skill' (4), responsibility (9), thinking outside of the box (1), thirst for knowledge (1). Management skills (re-categorised as an organising theme) identified decision making (1), foresight (2), leadership (**17)**, strategy (**24**), vision (**24**). Highlighted frequency counts aided in validation of most salient points, but most of the analysis was through the categorisation of participant meaning-making and the operational definitions therein. Thus, code frequency was used in HC & SC as a tool to highlight and organise certain responses to best answer the RQs.

An important note. This thesis applied a "reverse TNA" process by utilising deductive global themes first (Figure 5.2). For example, SC (global theme) and trust, relationships, networks (organising themes), then participants answers to the questions were mapped (basic themes) (Chapter Five). To reiterate, the difficulties in analysis centred around how to group (categorise) the responses (not necessarily the frequency of responses) because of the individual viewpoints (Chapter Six).

As an illustration, the challenges for coding SC focused on how to capture the salient points and organise the themes (Chapter Six). For example, skills, relationships and networks were dissected by identifying and utilising operational definitions (see codebooks Appendix K). Thus, "how to approach" people and relationships became an inductive organising theme to separate HC from SC to get the job done.

This was a painstaking process, but the operational definition for "approach" (e.g. a way of doing something; an act of *communicating* with another person or group to ask for something) became a useful category to capture participant meaning when discussing relationships (behaviour) versus networks (how to work together & share information). Furthermore, "communication" was coded as HC soft skill (e.g. people's ability to communicate with each other & work well together), but "how" people did this was categorised separately according to the operational definition.

Henceforth, the complimentary, challenging and symbiotic relationships between HC & SC are explained in (Chapter Five) and detailed in (Chapter Six). Moreover, inductive emergent themes and surprises (Chapter Five) was used to determine CSFs and detailed further to answer RQs (Chapter Six).

5.1.3.3 Data display

Quotation and code mapping was employed to organise and analyse the data. For example, NVivo Pro12 visualisation tools were used to display the quotation, code and network maps (Bazeley, 2013). All quotations have been edited to remove unnecessary wording and pauses in thought (e.g. "I think", "like", "so", "that" & so forth) for readership. No wording has been changed, but names or inferences to people or places have been removed and replaced with "Bob" or an edit in brackets (e.g. less proactive local authorities) to maintain anonymity (Sections 5.3 & 5.4).

In summary, data reduction, analysis and display techniques were followed through first, second and third cycle coding iterations to draw out the thematic network analysis relevant to answering the RQs and are presented in (Chapters Five & Six). Overall detailed data analysis can be found in (Appendix J.3).

5.2 Observation Findings: Procedure II & IV (Tier Two)

As explained in Procedure IV (Section 4.8.4) this researcher was invited to attend the Taskforce after meeting with a Welsh Government representative during the INCA Rural Gigabit conference. This invitation broadened the scope and understanding of the supplier challenges facing the UK Government, Welsh Government, local authorities, and relevant commercial suppliers. Details of the aim, agenda, attendees and purpose were explained in (Section 4.8.4, Table 4.2).

The Taskforce commenced in September 2019 as the Welsh Government's proactive response to the UK Government's announcement of the RGC programme (June 2019). The Taskforce is a "First in Wales" initiative and is explained further in the Welsh Government supplier interviews (Section 5.4). Details of the RGC programme were explained in (Section 2.3) with the "outside-in" approach and new vouchers focusing on rolling out "full fibre & 5G" to "hub" catchment areas (e.g. GP surgeries & schools). However, the final few and hard to reach areas were not included in this funding. In November 2019, the Welsh Assembly (WA) announced an additional £10 million "New Rural Community Fund" to assist those communities falling outside of the catchment areas.

5.2.1 Welsh Government Supplier Event (January 2020)

In January 2020, the Welsh Government Broadband Funding event was arranged to introduce the £10 million New Rural Community Fund and summarise the Taskforce activities to date (Section 4.8.4). The Cabinet Secretary for Economy and Transport is Ken Skates AM. The Deputy Minister for Economy and Transport is Lee Waters AM. The fund was introduced by the Economic Infrastructure Directorate which sits under Economy and Transport. Richard Sewell (Deputy Director of ICT Infrastructure), who reports to Lee Waters AM, presided over the event and explained that the final few and hard to reach 95,000 (k) properties in Wales has been an on-going problem over the last few years (hereafter referred to as the final 95k). This new fund has been

allocated to aid interested stakeholders, namely local authorities, and social enterprises, to find innovative solutions to connect the remaining final 95k. One of the core observations is a "local approach" is required (presentation PowerPoint slides, Appendix K).

During the January 2020 Broadband Funding Event, the Pembrokeshire County Council (PCC) gave a presentation of their "First in Wales" proactive approach as a local authority. To summarise the approach it has included: hiring two digital Engagement Officers (EO) who act as the community liaison, aggregating demand, organising both business and residential gigabit vouchers, putting the bid out to suppliers, negotiating with the suppliers and eventually assisting the rural communities in selecting which supplier offer they want to pursue. This is the first of its kind proactive approach and will be noteworthy to observe if the initiative is successful. The EOs were quick to state that it is not yet a case study, because it is a work in progress. Details of the new initiative are explained in the following (Section 5.4.2 & 5.4.3).

In addition, the Welsh Government updated the attendees on "Object Connect" which is the result of the Taskforce team's initiative to provide a central repository for collaborative working (Section 5.4.1). This portal can be accessed by local authorities and relevant parties can request access. The repository acts as a centralised hub to gather UK Government Barrier Busting legislation but updated in a devolved WA context. It contains updated "white premises" maps of Wales (Section 2.1.4). The organisation of the maps in itself is a complex process. The Taskforce representative responsible for updating the maps has to consolidate multiple sources of complex data from numerous commercial suppliers and local authorities involved in rolling out broadband within a geographical context. The Taskforce member has to incorporate these multiple data sets which are constantly being updated. It is quite a challenge, but the Welsh Government is working to keep these critical systems up to date and make them available to the local authority and subsequent suppliers to reach the final 95k.

One notable observation that will be explored further in the interviews. During the question-and-answer session, one attendee asked if the Welsh Government would consider what the UK Government has done by developing a Digital Infrastructure Investment Fund (DIIF) as opposed to grant funding in reaching the final 95k. An

investment fund approach could add an additional element to the Welsh Government strategy (GOV.UK, 2017, July 3). Richard Sewell admitted investment funding is not a Welsh Government skill set, but options are being considered. Conversely, this was the case for the UK Government who hired two qualified Investment Fund Managers to manage the money on their behalf. It was noted that the Welsh Government is not a commercial bank (INT13, CEO INCA), but the UK model could be employed to help resolve the problem. Suggestions were made about engaging with the Development Bank of Wales to enable this approach. Discussions on new funding options will be discussed in the interviews (Section 5.6.6).

Overall, Pembrokeshire is leading with a holistic digital strategy. Nonetheless, the WA is not necessarily focusing on "full fibre & 5G". The WA wants to ensure SFBB speeds and connectivity is the primary objective, because these can potentially be more achievable than "full fibre & 5G". Henceforth, the PCC strategy is considered an ambitious one and will be explained further in the exogenous supplier interviews (Section 5.4.2).

5.2.2 Wales Rural Digital Taskforce (September 2019 – March 2020)

The Welsh Government Broadband Supplier Event (January 2020) summarises the non-confidential core findings from Taskforce (e.g. collaborative working platform "Object Connect", detailed mapping exercises to aid full fibre network build & the new PCC local authority strategy).

Additional observations during the Taskforce meetings, includes a dynamic regional strategy in North Wales (Anglesey, Denbighshire & Gwynedd). This is due to previous investments by the Welsh Government to develop full fibre and 5G connectivity, such as Fibre Speed, by providing backhaul from Ireland and Manchester (INCA, 2019, May 24). It also includes a dynamic local authority leader who was recently promoted to Regional head. These initiatives are noteworthy but are considered outside of the scope of this case study.

Other local authorities leading in a proactive approach are Carmarthenshire (e.g. focusing on SME business development & actively following PCCs EO strategy) and Monmouthshire (e.g. leaders in trialling TV White space technologies to reach final 95k).

Mid-Wales is currently developing their digital strategies, similar to the Cardiff City Deals (CCD) and the Swansea Bay City Deals (SBCD). A significant correlation of funding opportunities is being presented through the Swansea Bay City Deal (SBCD). SBCD is receiving £1.3 billion (Swansea Bay City Deal, n.d) to develop innovation and 11 new projects in South Wales across four regions: Carmarthenshire, Pembrokeshire, Swansea, Neath and Port Talbot. Part of the SBCD is a South Wales Digital Infrastructure, so more funding opportunities, outside of UK Government and Welsh Assembly funding is available. This is potentially good news for the area.

In summary, the Welsh Government and various local authorities are taking a proactive approach, alongside UK Government funding, to ensure the final 95k white premises are not left behind.

5.2.3 Digital Pembrokeshire Broadband Project (July 2019 – ongoing)

In the September 2019 Taskforce meeting, PCC local authority announced its new and proactive response to resolving the digital divide in their constituency. The initiative is being driven by a dynamic leader (INT10, see Table 5.1), and subsequent IT delivery team (INT 5,6,7). Details of the vision and ambition for this initiative, and the relevance of the value of human & social capital, will be discussed further in (Section 5.4.2 & 5.4.3).

To date, the initiative has developed a "Digital Pembrokeshire" brand strategy: *"Ultrafast full fibre broadband for Pembrokeshire: Aspiring to a digitally inclusive Pembrokeshire"(Digital Pembrokeshire, 2019).* The core repository is the website (Digital Pembrokeshire, 2019), coupled with Facebook page (Digital Pembs, 2019a), Twitter feeds (Digital Pembs, 2019b), face-to-face (F2F) door to door campaign leaving leaflets and posters (Appendix K). The PCC team hired an IT consultancy to help develop an overall strategy plan to *"make Pembrokeshire the best digitally connected region"* (Pembrokeshire Council, 2019, August 1). The strategy originally identified over 300 projects, but closer investigation reduced the projects to 88, because of commercial supplier interest growing in the other areas. The remaining 88 project areas are an inclusion strategy to help the final few and hard to reach rural areas or as the website states *"About the digital connectivity programme in Pembrokeshire: 'a problem that won't fix itself"* (Digital Pembrokeshire, 2019). Hence, the proactive approach.

As stated, this new initiative is not yet a case study, but a developing initiative with positive feedback thus far. Details of the feedback will be explained in the exogenous supply interviews (Section 5.4.2 & 5.4.3) and the endogenous demand interviews (Section 5.8.5). Optimistically, it will develop into a successful case study because the potential for a local authority proactive approach could help bridge the digital divide.

5.2.3.1 Pembrokeshire County Council (PCC) Pilot Scheme – A new development

To start the process four pilot project areas have been identified (Figure 5.3). Furthermore, one of the pilot projects includes this study's case study area. This new development has changed the construction of the conceptual framework to a "top down" local authority approach, versus a rural community "bottom-up" approach but makes for a novel pre and post addition to this research.

Notably, the pilot study area is greater geographically than the concentrated "final few" area where this case study is located. The Splits-Ville case study includes 20 property hamlets, whilst the pilot project includes 365 properties and crosses Ward boundary lines. Details of the pilot project area will be explained in (Section 5.4.2). This new development within the case study area has adapted the focus of this thesis, and subsequent research instruments (see divergence change records Section 4.10) but with potentially more attention-grabbing results.

Figure 5.3 Digital Pembrokeshire Strategy – four pilots projects (Digital Pembrokeshire, 2019)

5.2.3.2 Digital Engagement Officers (EO)

A critical part of the PCC digital strategy was to hire two digital EOs who are taking a proactive approach to speak face-to-face (F2F) with rural communities. The EOs were hired in July 2019. The EOs job description is to gauge interest in "full fibre & 5G" and aggregate demand to maximise voucher value and coverage and negotiate with suppliers on behalf of rural communities. This strategy is summarised the eight-stage model identified in (Section 3.5.1.1, Table 3.9), but instead of the onus being on the rural community, the local authority will be fulfilling that role. The outcomes of this finding will be discussed through the interviews.

The "Digital Pembrokeshire" brand campaign includes the EOs announcing their presence and taking initial feedback surveys during the Pembrokeshire County Fair in August 2019 (Digital Pembs, 2019, September 16). Pembrokeshire residents had the opportunity to meet the EOs and hear about this new proactive approach for the County. Outcomes of this initial survey are on the Facebook and Twitter pages (Digital Pembs, 2019, September 16) (Appendix K). Observations from the Taskforce witnessed other local authorities following Pembrokeshire's lead and subsequently hiring digital EOs in their constituencies (e.g. Carmarthenshire, Ceredigion & others are following suit).

5.2.4 Conference findings – RSA, INCA & UK5G (May-June 2019)

The primary findings from the conferences are the results of a five-year governmental study on the impact of the SFBB exploitation programme for SMEs (RSA, 2019, May 22) and the subsequent networking contacts made at this event. The INCA conference was a primary hub for this researcher with the introduction of the RGC programme and subsequent networking at this event (INCA, 2019, May 24). The UK5G funding event introduced the DCMS call for consortiums, partnerships, feedback on how to improve DCMS funding programmes and the introduction of new funding allocation for supply and demand initiatives to develop 5G ecosystems (DCMS, 2019, June 19). The key themes throughout these conferences were the collaboration, knowledge share networking and partnership opportunities within the RGC and 5G ecosystems. The supplier feedback from these events lead to the DCMS revising how it allocates funding which resulted in a new "Dynamic Purchasing System" (DPS). This will be

explained further in the interview findings (Section 5.6.7). Overall conference findings will be discussed in (Chapter Seven).

5.2.5 Summary of observations (Tier Two) (RQ1, 2 & 3)

To summarise the emergent themes and surprises identified during the observations, includes the "First in Wales" initiatives (RQ3) and "proactive" approach to connecting the final 95k white premises by the Welsh Government and the PCC (e.g. centralised hubs to focus on local authority & rural community engagement). These initiatives highlight the value of human & social capital (RQ1). It is people with leadership drive, skills, strategy and vision (e.g. human capital productivity). It is the relationships and networks providing the knowledge share, lessons learned and best practice that assists others to make things happen in their areas (e.g. social capital collective action). The increasing shared financial capital (SFC) opportunities (e.g. DIIF, DPS, new £10m community fund alongside existing vouchers & SBCD digital infrastructure funding). The value of human & social capital resources that support SFC funding distribution provide multiple learning and cooperative interplay opportunities (RQ2) to reach the final 95k (explained further in Chapter Six).

In addition, the conferences and events act as centralised hubs for collaboration, knowledge share, networking and partnership (consortium) opportunities (RQ1 & 2). Numerous innovation analysis (IM) and potential intervention areas will be discussed in (Chapter Seven). Overall, these new developments make this a unique research opportunity and the adjustments to the conceptual framework, interview guides and outcomes were accounted for in the divergence records (Section 4.10).

5.3. Interview Findings: Exogenous Supply (Procedures V)

The rural community is the unit of analysis, but both exogenous supply and endogenous demand stakeholders needed to be interviewed to understand the various challenges and opportunities being presented by all stakeholders. Interviews were selected with specific relevance and expertise to the case study area in Pembrokeshire, South Wales. MBs are identified as relevant and contributing deep rural stakeholders and were interviewed as such. Interviews were coded according to the data analysis procedures and *a priori* codebook presented in (Section 4.11.2, Appendix J & K).

5.3.1 Overview of exogenous supply participants

A summary table of the exogenous supply-side interviews are included in the following (Table 5.1). Data collection includes general information gathering and formal semi-structured interviews. Some interviews were conducted more than once with specific individuals because of their expert knowledge within the specific case study area.

Table 5.1 Summary of exogenous supply interviews

Code	Supply Interviewee	Interview length	Time in post	Purpose
INT2	Welsh Government (Mr. P)	2 x 30-90 minutes	5 years	Information pre & post case study selection: 2018 and 2019
INT3	Openreach	3 x 30-45 minutes	Not known	Technical information pre & post case study: 2019 and 2020
INT4	Local authority	1 x 90 minutes	15 years	Information overall big picture: Digital Infrastructure
INT5	PCC Local authority	1 x 60 minutes	8 years	Information pre case study: follow up with interview
INT6	PCC Local authority	1 x 90 minutes	10 months	Information pre case study: follow up with interview
INT7	PCC Local authority	1 x 90 minutes	10 months	Information pre case study: follow up with interview
INT 9	CEO Altnets	1 x 30 minutes	10 years	Information pre case study: overall big picture
INT7	PCC Local authority	1 x 60 minutes	10 months but over 7 years of community experience	Interview
INT10	PCC Local Authority Leader	1 x 90 minutes	8 years	Interview
INT12	Welsh Government	1 x 60 minutes	7 years	Interview
INT14	Welsh Government	1 x 60 minutes	6 years	Interview
INT15	Welsh Government	1 x 60 minutes	7 years	Interview
INT16	Openreach Community Fibre Partnership	1 x 75 minutes	1 year, but over 10 years of community experience	Interview
INT18	Openreach Community Fibre Partnership	1 x 45 minutes	18 months, but 20 years at BT	Interview

As a result of the "First in Wales" initiatives presented in the observations (Section 5.2) and by adapting the focus of this research to accommodate those changes, interviews with the PCC initiative were conducted and the value of HC & SC is evidenced (Section 5.4). To repeat, the PCC Team raises caution because they are in a trial-and-error situation and want to evaluate what works and what does not. There are still challenges to overcome, but this initial vision, strategy and engagement is noteworthy. How it transpires is yet to be seen, but as some of the exogenous supply interviewees have stated "*you have to try*" (INT9, INCA; INT10, PCC; INT 12, Welsh Government) (Table 5.1).

5.4 Welsh Government interviews – "First in Wales"

It became apparent during the various supplier interviews there are additional "First in Wales" initiatives. A total summary is as follows:

1. Wales Rural Digital Taskforce (Welsh Government) - first time initiative to collaborate with local authorities on how to resolve the final 95k.
2. Pembrokeshire County Council (Local Authority) – a proactive and ambitious first-time initiative, and potential for new funding strategies.
3. Openreach (commercial supplier) – developing a stronger presence in Wales, strategic partnerships, and hiring Rural Engagement Officers (REO) dedicated to reaching the final few.
4. Alternative Networks (commercial supplier)– a "Wall of Money" with £billion firms wanting to invest pension funds into the "fourth-utility" Infrastructure (e.g. electricity, gas, water & now digital infrastructure). In addition, the potential for the Welsh Government to adopt a "Digital Infrastructure Investment Fund" (DIIF) approach.
5. "Do it Yourself" (DIY) options – Ofcom Code Powers released for local communities to build their own networks (e.g. Shared Spectrum Access (SPA) & Pole Infrastructure Access (PIA).

These initiatives, and the value of HC & SC therein, will be explored in detail in the following sections.

5.4.1. First in Wales – Welsh Government Taskforce

The following quotation maps (e.g. data displays) explain how and why the Taskforce was implemented as a new initiative and strategy to reach the final 95k in Wales. The initiative has many facets, including the dynamics of the proactive Welsh Government team driving these initiatives. These new initiatives present opportunities and challenges, which include legacy contractual issues over stranded assets, the boundaries of State Aid, and clawback clause expenditure.

Working with local communities and providing centralised repositories has been active in England and Scotland since 2017/2018 (DCMS, 2017). The DCMS Barrier Busting Taskforce commenced in October 2017 and includes a Local Community group to develop best practice with access to the "Digital Connectivity Portal" (DCMS, 2018, December 20). The Digital Connectivity Portal is organised around the following themes: access to public sector assets, digital vision and leadership, planning process and policies, street works and wayleaves (DCMS, 2018c). Nevertheless, this first initiative in Wales is focused entirely on reaching the final 95k with a dedicated proactive local authority approach. The Taskforce "Object Connect" portal provides a "one stop shop" and customised information relevant to this aim.

5.4.1.1 Why the Wales Rural Digital Taskforce?

It is the first dedicated initiative to work with local authorities to reach the final few. It was a "lightbulb" moment and realising the value of local insight, local knowledge, and local relationships was required to resolve the complexities reaching the final 95k. The following quotation map captures the rationale (Figure 5.4).

Figure 5.4 First in Wales - The Taskforce - quotation map

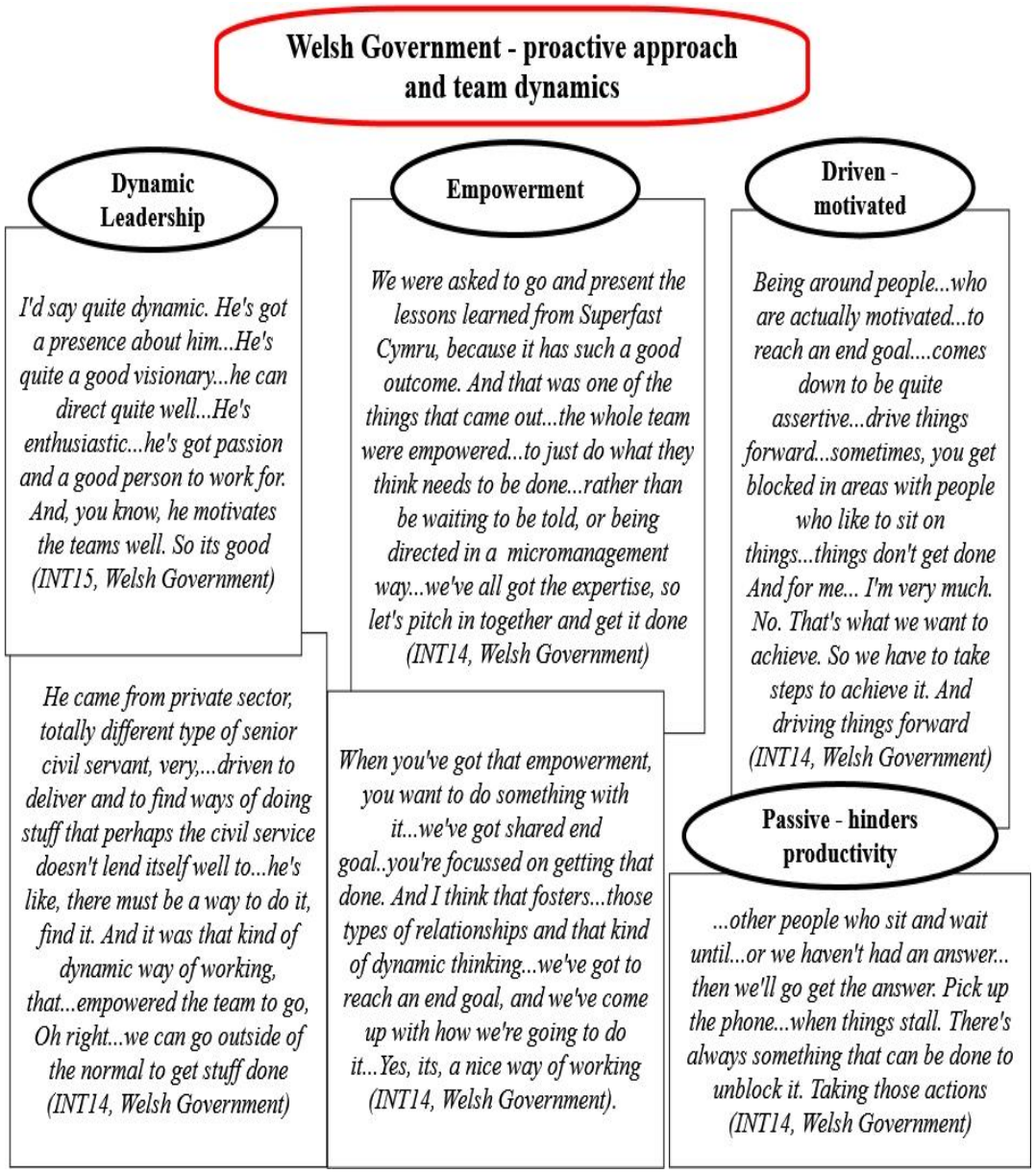
In summary, the Welsh Government recognised it required the local authorities to help reach the final 95k. The local knowledge, local relationships and the inspiration of the proactive local authorities influence the less proactive local authorities. The Taskforce is a centralised hub to facilitate best practice, knowledge share and networking for collective action.

5.4.1.2 The value of HC & SC – Leadership & team dynamics (RQ1)

Leadership, empowerment, strategy and vision all contribute to the proactive approach evidenced by the Taskforce team. The “can do” attitude was observable by this researcher during the Taskforce meetings. During the interviews about the value of people (HC) and relationships (SC) to “get things done” and reach the final 95k, these attributes were evidenced. The personal attributes (qualities) of the leadership team

and how "dynamism, enthusiasm & vision", empowered, inspired and motivated the team to become a winning formula. The Taskforce interviewees were selected because one won an award for the successful outcome of Superfast Cymru (INT14, Welsh Government) and the other is a leader for reaching the final 95k (INT15, Welsh Government). The overall leadership, subsequent team dynamics and the value of proactive personal attributes is evidenced in the quotation map below (Figure 5.5). Note the converse to proactivity is "passivity" or hindrances to HC productivity and getting things done. More specifically, the details of counterproductive (or negative) personal attributes and the hindrances therein will be explored further in (Chapter Six).

Figure 5.5 Taskforce proactive approach and team dynamics - quotation map



In summary, the recognition by the delivery team that an empowering leadership team helped them succeed in their goals is noteworthy. This finding is echoed in PCC leadership and delivery team (Section 5.4.2) and will be explored further in (Chapter Six).

5.4.1.3 Complexities – Stranded assets, state aid & time-bound contracts (RQ2)

During a field visit to the case study area, the Ward Councillor (INT6) drove this researcher to an adjacent remote rural area to show cables hanging from a telephone pole in the middle of the hamlet (Figure 5.6). During the interviews with Welsh Government, this researcher asked why this is the case? It became apparent, that this is a recognised problem by all relevant supplier stakeholders who refer to this situation as "Stranded Assets".

In brief, the Superfast Cymru Project (2011/2012) was target based. The Welsh Government did an Open Market Review (OMR) and invited bids for 767,000 (k) premises to enable fast broadband. The contract states that to *"meet the terms of the contract and to get paid, they have to provide access to 90 percent of that intervention's area…90 percent of the 727k, which came out to about 690,000 (k) if they didn't reach that percentage figure, then we could impose liquidated damages and penalties on them"* (INT15, Welsh Government). To ensure BT (who won the bid and secured the contract) met that target they over built, *"…in the areas that they overbuilt…they ended up kind of* ***running out of time****. So that resulted in quite a few cabinet's being stood, but not powered. Fibre being rolled out, but not connected. And that's been termed as stranded assets…but we didn't pay for any of that"* (INT15, Welsh Government). This was at Openreach's own expense. If what they have done *"hasn't provided access to a premise, or premises. Then we don't pay for it"* (INT15).

5.4.1.3.1 State Aid rules

Governmental procurement policies are there for a reason. To ensure taxpayer money is spent with accountability measures in place. Details of State Aid rules and procurement policies are beyond the scope of this inquiry. Nonetheless, it is necessary to understand some of the challenges both parties face when fulfilling time-bound contracts and operational challenges to deliver SFBB and "full fibre & 5G" to rural areas.

The crux of this situation is not easy to clarify, but in an attempt to summarise, when Openreach overbuilt under the terms of the original contract, these premises were re-classified under the new procurement contract as “Under Review Premises”. This categorisation meant that they could not be included in the new procurement terms and conditions as an “intervention area”. These “under review premises” could or should have been completed under the terms of the original contract, and/or allowed some flexibility in the State Aid rules to accommodate for these, but for various reasons, explained below in Welsh Government and Openreach’s response, they were not completed. Hence, they are now classed as “Stranded Assets”.

Figure 5.6 Stranded assets - adjacent hamlet in Pembrokeshire

5.4.1.3.2 Dialogue to understand the challenges

In an attempt to understand the complexities and subtleties, below is the dialogue between this researcher and INT15 (Welsh Government). Please note, this is not an exhaustive understanding of the details and finesses of State Aid. It is simply an attempt to comprehend stranded assets as unconnected sources in rural areas.

Researcher *- But with these stranded assets, I still can't quite get. And so are those being taken into any* ***Local Authority planning****.*

INT15 *- They can be now. Again, it goes back to State Aid rules and regulations…We've done a number of Open Market Reviews. The first one was 2012, and that resulted in the main contract being let. We've ended one in 2014, which resulted in additional premises being put through the original contract. And we did one in 2017, which resulted in the new procurement…when we did the one of 2017, these stranded assets could still have been completed…we had to categorise these, as what we call Under Review Premises, which meant that, in the new procurement…they couldn't be included in the intervention area of the new procurement...it all sounds…bizarre, because you think it makes absolute sense to get these communities up and operational and have the asset is already there. But State Aid rules wouldn't allow us to do it.*

Researcher *- Why? It doesn't actually make common sense. Can you explain?*

INT15 *- I can try...So, in 2012,* ***BDUK would negotiate a State Aid decision, with the EU for the State Aid,*** *that would be given to whoever to deliver these contracts.*
…as part of the State Aid decision before any aid is given. You have to carry out an Open Market Review. The result of that OMR has to then inform a procurement which ***has to take place within six months*** *of the OMR…the procurement can only deliver to white premises. The difficulty we had with the stranded assets, is that at the point of procurement, they were classed as* ***Under Review, because they still could have been completed,*** *because BT were still rolling out* ***on the original contract…****we went out for active procurement for the new one.*

So, there was an overlap*. It is a…bizarre situation, but we were just bound by. I mean, people go on about EU rules and regulations and this is one of them, unfortunately. But if we break that rule or regulation,* ***then it would be unlawful State Aid*** *that we'd be giving to Openreach, and they would have to pay it back.*

Researcher *- All because that stranded asset is sitting there, and it's now been re-classed as an Under-Review Premises.*

INT15 *- Now, we just completed another OMR.*

Researcher *- Oh so it's the overlap from the old to the new.*

INT15 *- Yes. So, the 2019 OMR they will be* ***classed as white****. So, we can…through the grant, the new funds.*

Researcher *- And that* ***new fund you are now free to put whatever terms and conditions you want on it.***

INT15*- Yes.*

Researcher *- You are not bound by the EU.*

INT15 *- We are, but the State Aid measure that we're using for the grant fund, is the general block exemption rules. So all we have to do for that basically is to notify the EU, that we're setting up this grant and then any scheme that comes in over 500k Euros needs to be notified…but that's the only restrictions that we got. So,* ***it's a much more flexible process****.*

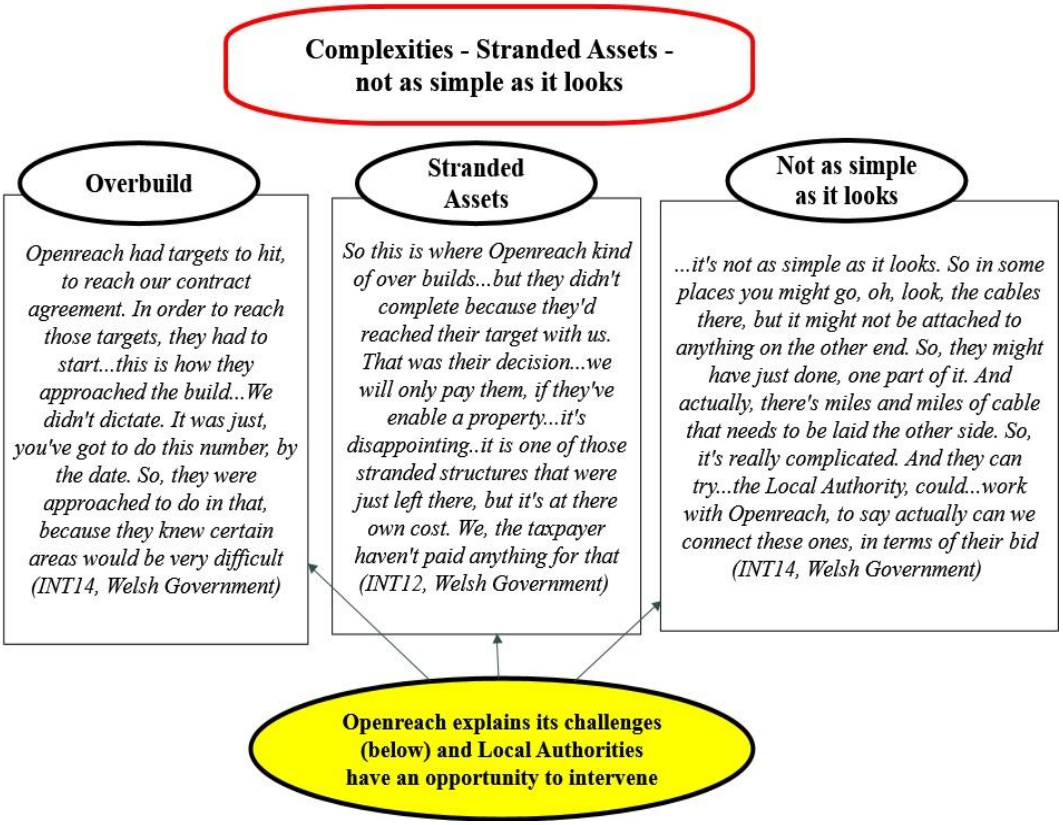
Bold emphasis *added to highlight issues contributing to complexities*

In summary, there are State Aid rules and regulations that need to be followed. However, some flexibility and feedback on time constraints are noteworthy. Openreach explains its challenges and response to stranded assets below (Section 5.3.2) and it is *"not as simple as it looks"* (INT14, Welsh Government).

5.4.1.3.3 Complexities – Not as simple as it looks

The complexities involved in building a full fibre network is a core finding in this thesis (Figure 5.7). It is easy to criticise State Aid rules, procurement policies or how the contracts are executed, but to be fair to all parties, these things develop over time. The above dialogue is addressing legacy issues in rolling out SFBB since 2012. The new Governmental ambitions to roll-out "full fibre & 5G" is another layer of architecture, funding and procurement. State Aid needs to account for £hundreds of millions of taxpayer money, so it is too simplistic to criticise without a full investigation into this area, which is beyond the scope of this inquiry. This is a snapshot of the complex exogenous supplier ecosystem challenges in reaching the final 95k and resultant developments (e.g. DCMS Dynamic Procurement System (DPS) response to market feedback). The DPS will be explained below in (Section 5.6.3).

Figure 5.7 Complexities - not as simple as it looks - quotation map



In summary, every business is bound by contractual issues and need to make difficult choices to deliver within the selected time frames. Despite the legacy challenges from SFBB Cymru, there are multiple opportunities for local authorities to engage to fill these gaps. The potential intervention opportunities will be discussed further in (Chapter Seven).

5.4.1.3.4 Opportunities - Clawback clause – local authorities (RQ1, 2 & 3)

One final assessment is the success of the Superfast Cymru Project resulted in £80 million in clawback clause funding because take-up of SFBB in Wales was higher than expected. The clawback clause has not been capitalised on by local authorities, despite it being a massive incentive and funding opportunity to reach the final 95k (Section 2.3.4). One of the challenges the Welsh Government is currently addressing is the Openreach stipulation that the clawback clause be reinvested with them and not with competitors (INT15, Welsh Government). This is currently in discussion, but this researcher would assert that the £80m could and should be spent by the Welsh Government and local authorities on reaching the final 95k. For example, £80m divided into 95k white premises equals approximately £800,000 (k) per property, plus the new £10m community fund could mean approximately £1 million per white premise.

5.4.1.3.5 Mutual learning & local authority intervention areas (RQ2 & 3)

In conclusion, the salient points to address are the pressures of *time-bound* contracts, State Aid *flexibility* is required to accommodate for these anomalies, and the categorisation of "under review" versus "white premises" to target *intervention areas*. As detailed in the dialogue, the positive news is the recent flexibility in State procurement at local-authority level. This is a critical point to answer RQ2 (e.g. mutual learning & cooperative interplay) and will be discussed further through the new DPS (Section 5.6.7). Moreover, there is potential for local authority intervention to include the stranded assets in their planning and capitalise on the *clawback clause* funding.

5.4.2 First in Wales – Pembrokeshire (PCC) Local Authority

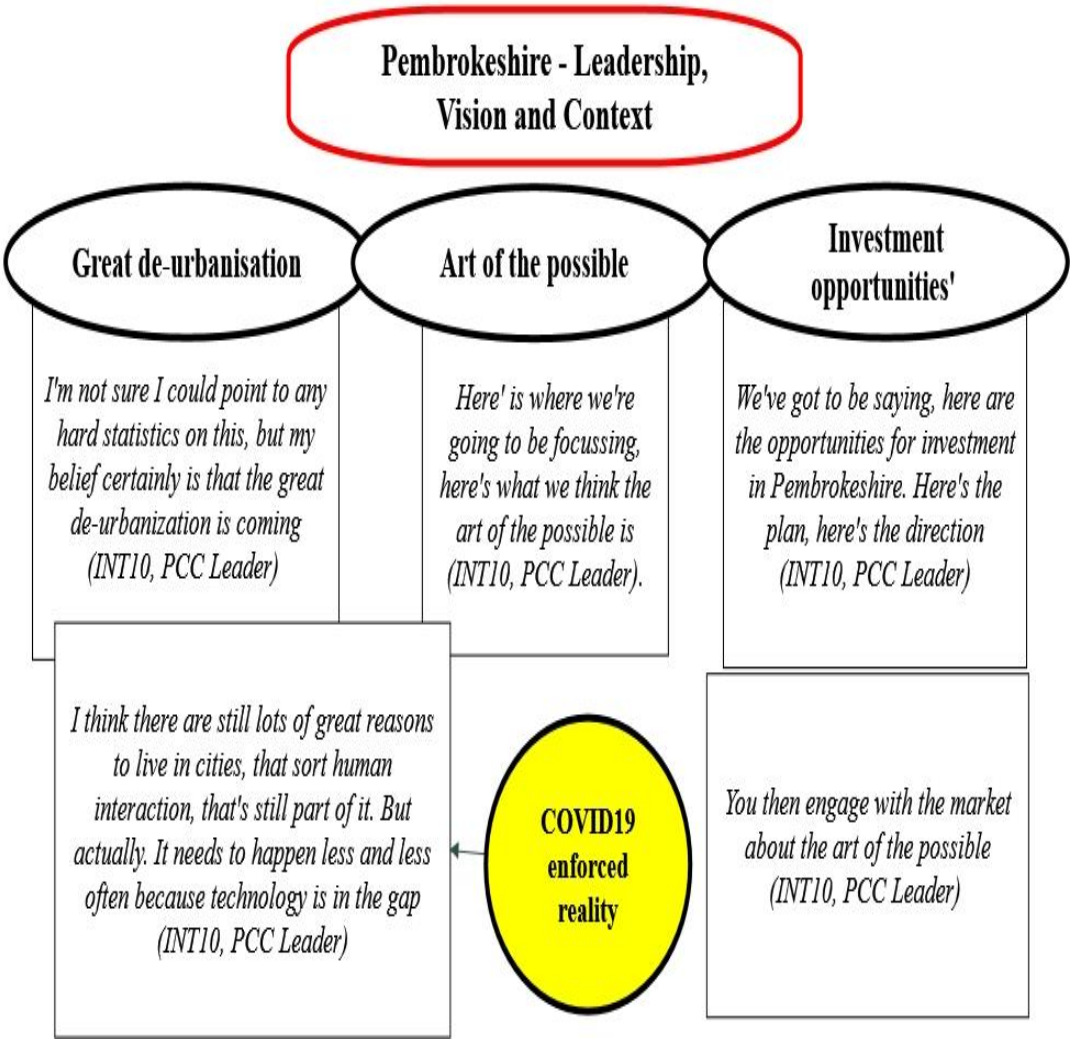
INT10 (PCC Leader) is one of the dynamic leaders driving "full fibre & 5G" in Pembrokeshire. This leader currently divides his time between London and Pembrokeshire. He is an economics graduate and consultant in London (e.g. high level of HC & SC). The leader's vision is for Pembrokeshire to become a place for

investment and 21st century living (e.g. work from home, rural lifestyle, ability to commute to capital cities from Pembrokeshire). The PCC leader's motivation is for Pembrokeshire become the *"best digitally connected county*" (Figure 5.8), hence the ambition for a full fibre strategy.

5.4.2.1 The value of HC & SC - Leadership, vision & context (RQ1 & 3)

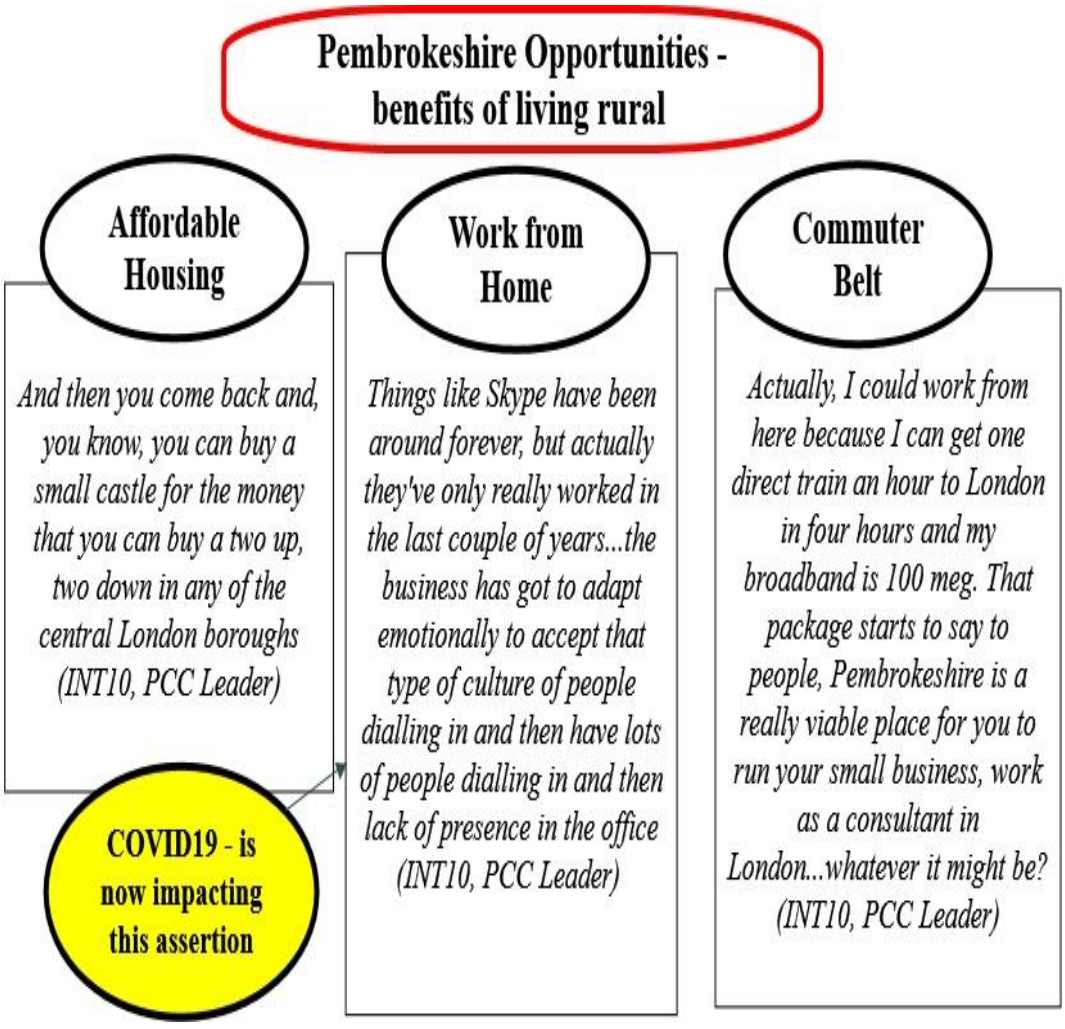
The role of this PCC leader is to develop the economy for Pembrokeshire; thus, it is an integral part of the job. However, "how" he approaches the role is of relevance to this thesis. The value of HC (e.g. proactive, leadership, vision) and SC (e.g. relationships & networks) is evidenced in their approach. What follows is the interviewees (INT10, PCC Leader) vision for Pembrokeshire and the opportunities and challenges the county faces in manifesting that vision (Figure 5.8).

Figure 5.8 Pembrokeshire leadership, vision & context - quotation map



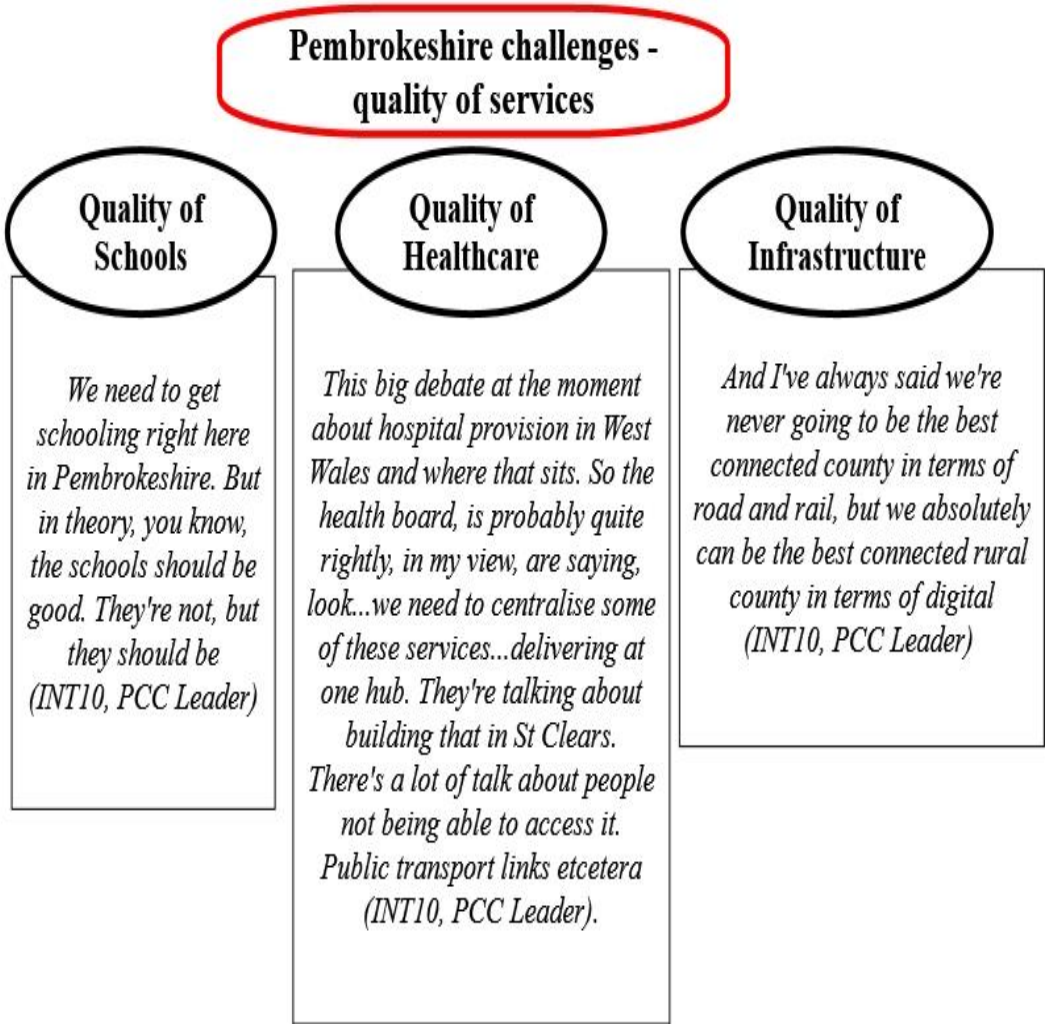
The "great de-urbanisation" refers to people moving out of urban environments because the potential benefits and quality of life is perceived to be greater in the countryside versus congested and expensive capital cities (e.g. more affordable housing, cleaner air, less frenetic lifestyle, work from home & so forth). The vision the PCC leader (INT10) has for Pembrokeshire identifies the opportunities (e.g. for investment, working from home, commuter belt to capital cities) (Figure 5.9).

Figure 5.9 Pembrokeshire opportunities - benefits of living rural - quotation map



Nonetheless, there are challenges to overcome to improve the quality of healthcare, infrastructure and schools (Figure 5.10). It is critical to note that all of these statements of the opportunities and challenges of living in Pembrokeshire are corroborated (triangulated) by the demand interviews (INT1, LDC SV-A; INT8, LDC SV-B) and reasons why they moved to the rural community (Section 5.8).

Figure 5.10 Pembrokeshire challenges - quality of services - quotation map

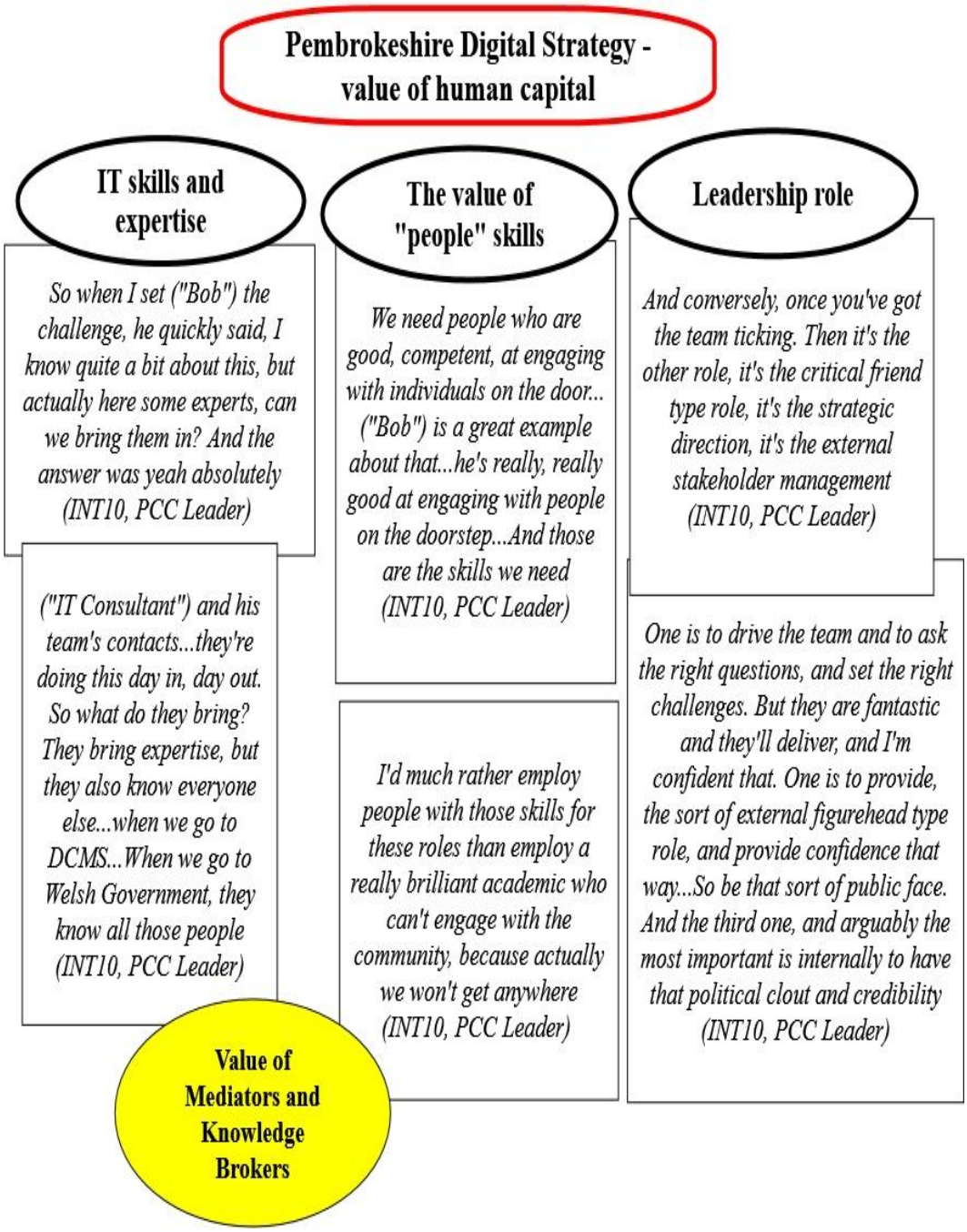


Despite the challenges, the PCC leader's vision (INT10) is to make Pembrokeshire a desirable place to live (Section 5.2.3). The PCC leaders view is that there is a significant amount of HC, SC and SFC in the cities with greater earning potential and spending power. To attract these people to relocate to Pembrokeshire could develop the economic prosperity in the area. In relation to the COVID19 outbreak, this prospect could become more of a reality as rural living attracts a more balanced lifestyle to the expensive and frenetic pace of congested capital city living.

5.4.2.2 The value of HC & SC - Developing the PCC digital strategy (RQ1, 2 & 3)

The PCC leader gives full credit to the PCC IT team (Figure 5.11). The Head of IT (INT5, PCC) was one of the driving forces in collaboration with an IT Consultancy firm hired to assist in applying for a Local Full Fibre Network (LFFN) grant. The PCC stated how the HC (e.g. IT & grant proposal skills and knowledge) and the SC (e.g. relationships & networks) of the IT consultants was valuable because they had pre-established relationships with DCMS and the Welsh Government.

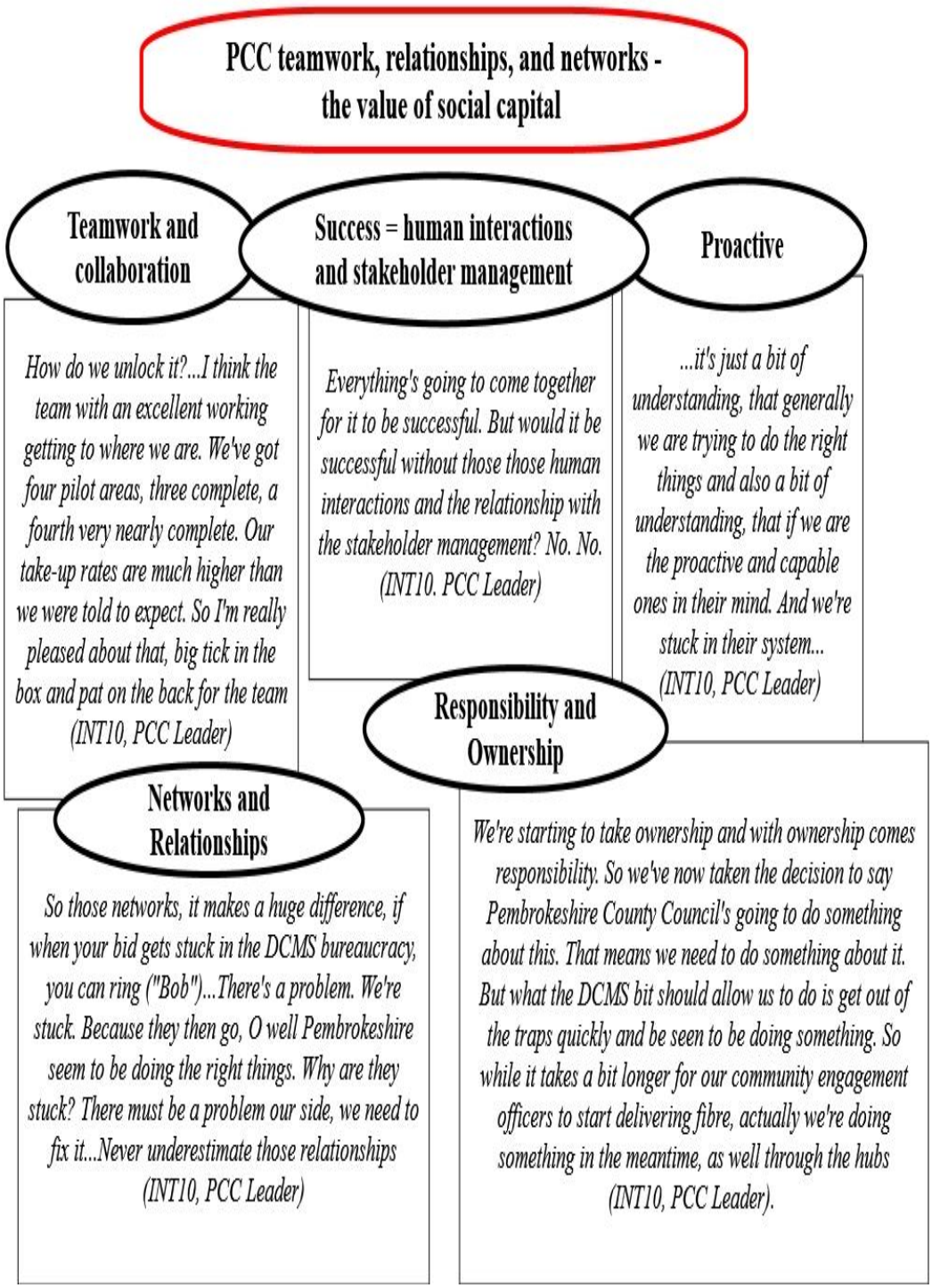
Figure 5.11 PCC Digital Strategy - value of human capital - quotation map



5.4.2.3 The value of SC – Relationships, networks & teamwork (RQ1, 2 & 3)

Outside of the value of the IT skills (HC) and internal stakeholder collaboration (SC), are the external stakeholder relationships and collaboration opportunities (SC). Examples of this are stated by the PCC leader (INT10) in the following (Figure 5.12).

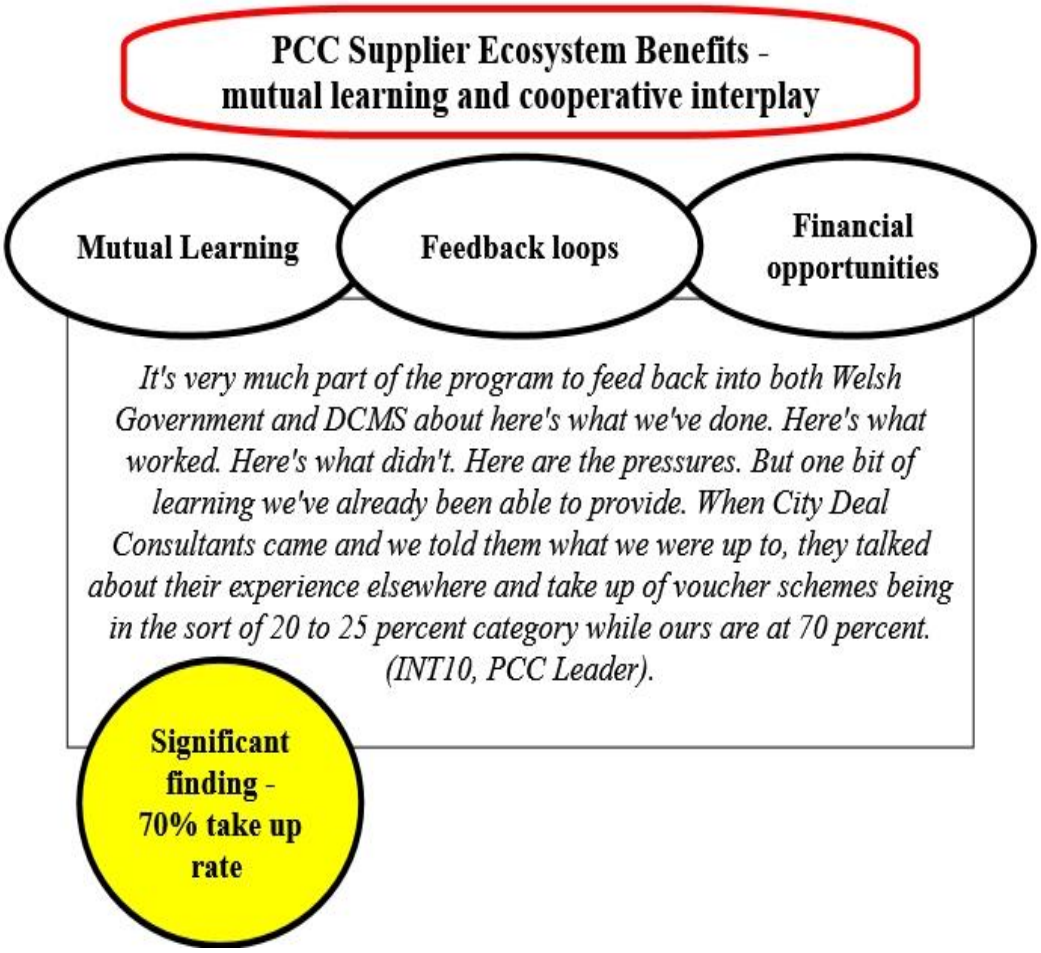
Figure 5.12 PCC teamwork - value of social capital - quotation map



5.4.2.4 Mutual Learning – Take-up rates - Feedback loops (RQ2)

A significant finding from the PCC Digital Strategy is the reported take-up rates in the pilot project are 70% (INT10). This is a significant statistic because it will attract investment for both local authority (e.g. clawback clause) and private investment (e.g. pension funds) (Figure 5.13).

Figure 5.13 PCC - mutual learning & cooperative interplay - quotation map



5.4.2.5 Multiple financial capital (FC) opportunities

The PCC Pilot Scheme strategy included mapping every premise within the project boundary. For example, this included commercial, flats, military, residents, sewage and SMEs to include as many premises as possible to identify the demand and coordinate the maximum use and efficiency of the vouchers (INT5, PCC IT).

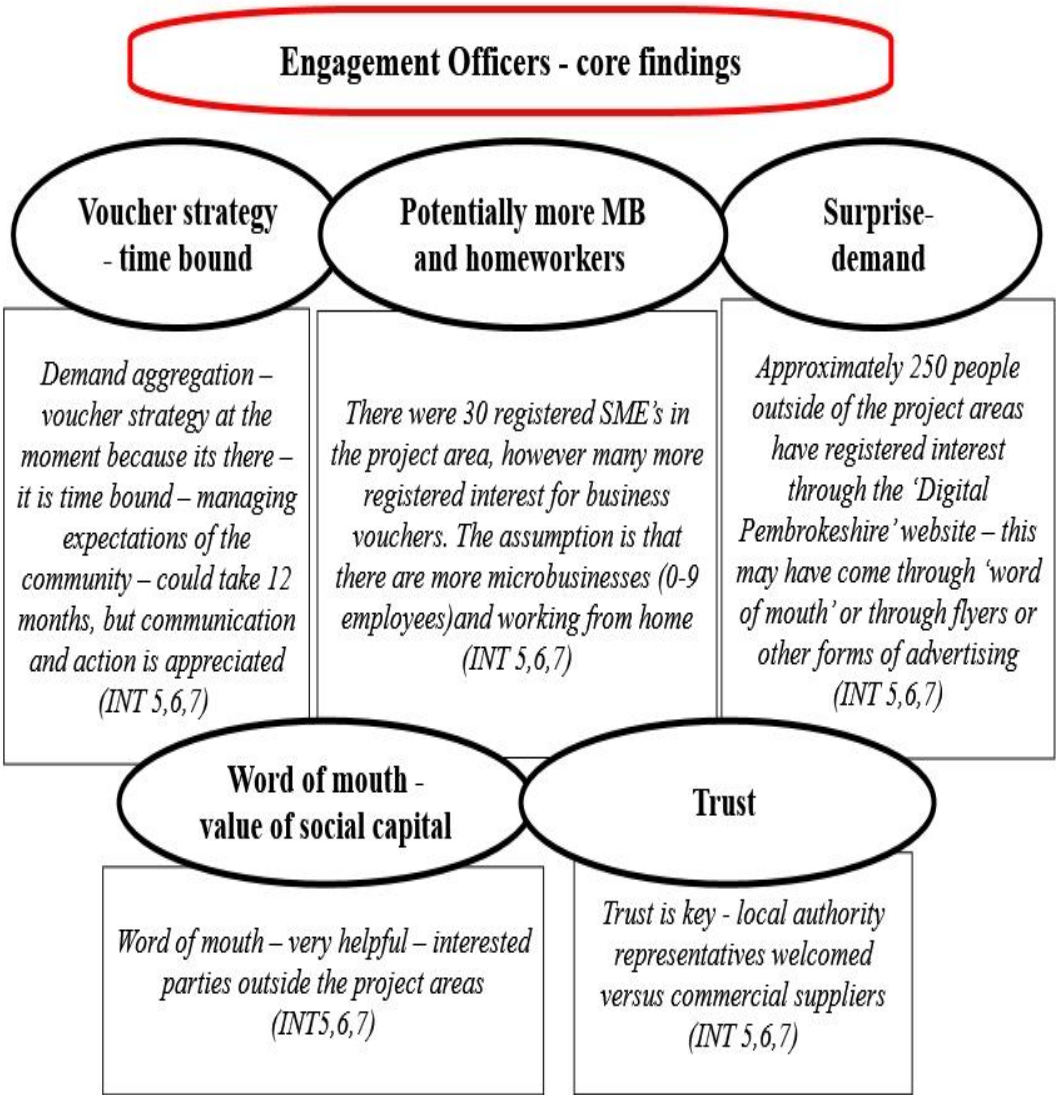
There are multiple local, regional, and governmental funding initiatives being coordinated in Pembrokeshire. To reiterate, as of March 2020, the UK Government funding includes LFFN grant proposal and RGC voucher funding (e.g. for schools & GP surgery hubs). Additional Welsh Government funding includes existing ABC vouchers and gigabit voucher top-ups (Section 2.3), plus the new £10m community fund (Section 5.2.1). The PCC local authority included a £2 million gap fund to assist areas where the initiatives fall short. Additional regional funding will soon be allocated to Pembrokeshire from the Swansea Bay City Deal (SBCD), and the distributions of the additional £5 billion announced by the UK Government funding. Moreover, the "Wall of Money" from private investment can be accessed through demand (e.g. take-up rates) and robust business models in addition to governmental funding.

It is this researcher's assertion that there is a large quantity of financial capital available within the ecosystem. Who and how this financing is accessed and distributed is up to the local authorities and proactive rural communities who want to attain it? The potential SFC intervention areas will be discussed further in (Chapter Six & Seven).

5.4.3 First in Wales – Engagement Officers (EOs)

The core findings from the PCC interviews (INT5, IT; INT6, EO; INT7, EO) reveal similar previous time-bound pressures the other State Aid initiatives have faced (e.g. new gigabit voucher funding is timebound). Nevertheless, there are significant findings and opportunities to be explored to answer (RQ1, 2 & 3). For example, the value of HC (e.g. people skills & local tacit knowledge) and SC (e.g. word of mouth or free of charge advertising, the surprising increased demand as a result, the value of trust with EOs on the door-step versus commercial door knocking) (Figure 5.14).

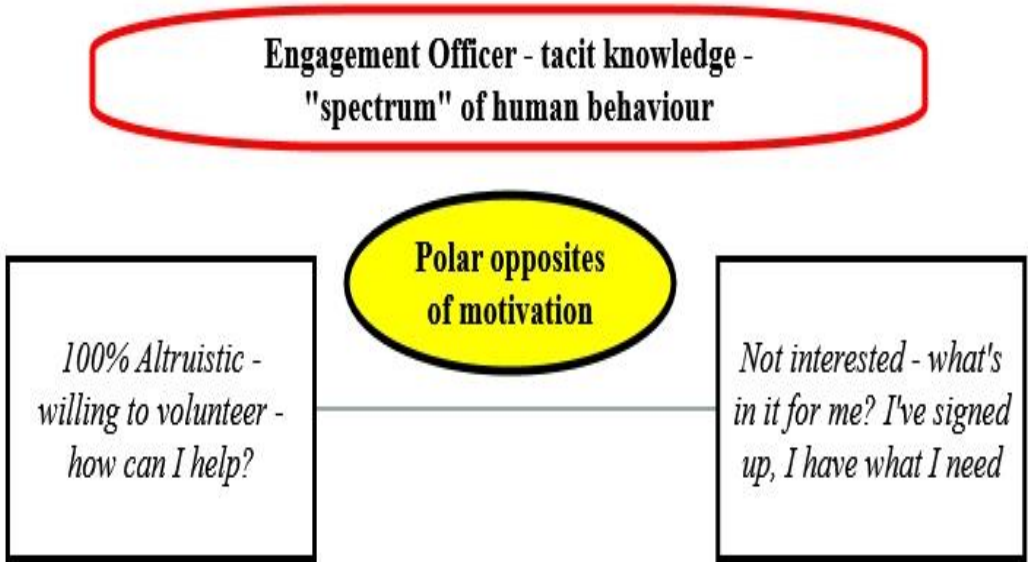
Figure 5.14 Engagement Officers (EO) core findings - quotation map



5.4.3.1 EOs – Value of HC – Local tacit knowledge (RQ1 & 2)

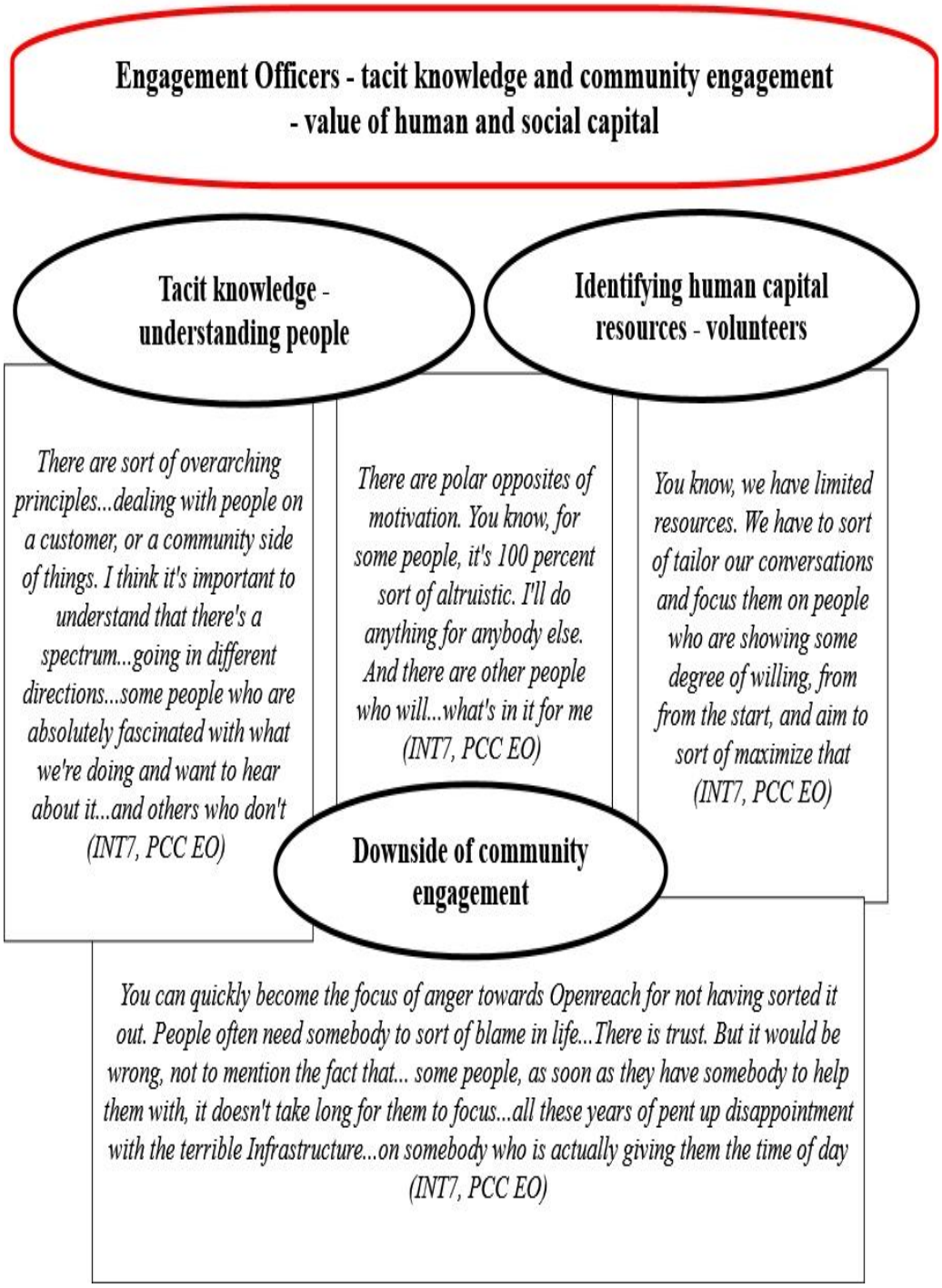
One interviewee (INT7, PCC EO) has a considerable amount of HC & SC when working with communities. One notable finding is the local tacit knowledge developed through years of working with people and communities. The interviewee calls it the "spectrum" of human behaviour (e.g. some people are 100 % altruistic, compared to others who are not interested or "what is in it for me"?) (Figure 5.15).

Figure 5.15 EO - value of human capital - tacit knowledge – coding results



This valuable tacit knowledge is useful in recognising who in the local community might volunteer and support the EOs in delivering NGA access because of limited resources (e.g. non-financial asset). Another core finding is that although the EOs are viewed as a positive relief for rural residents to have local authority support, one potential negative outcome is that over time the rural residents may focus their anger at the EOs versus the government or commercial suppliers. The EOs are now "in the middle" and the "face of negotiations". These findings are described in following quotation map (Figure 5.16).

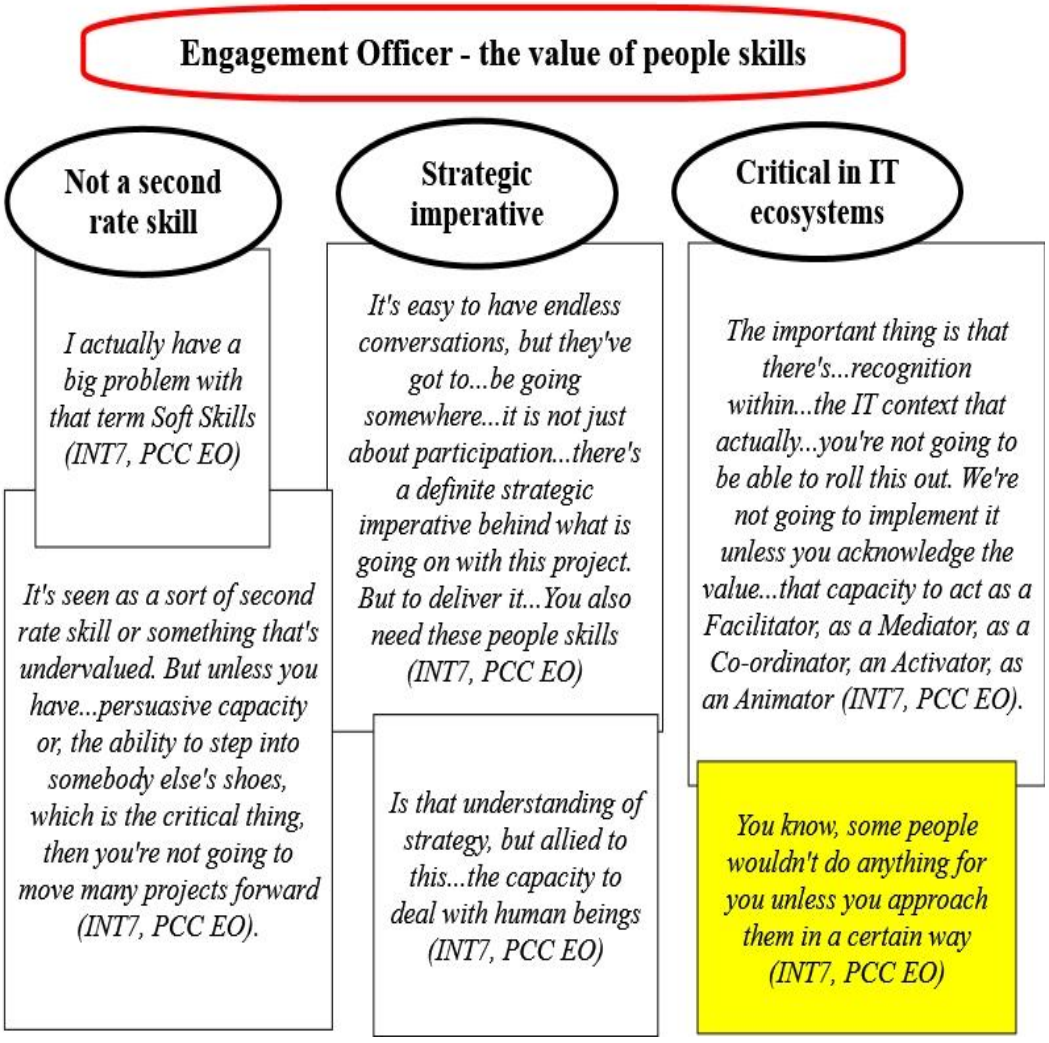
Figure 5.16 EO - value of HC & SC – community engagement - quotation map



5.4.3.2 EOs – Value of HC - "People" & soft skills (RQ1)

Regardless of whether or not the local authority capitalises fully on the financial capital available, one of the core findings from the interviews was the value of the "people skills" the EOs aimed to procure when dealing with the public (Figure 5.17).

Figure 5.17 EO - value of human capital – people skills - quotation map

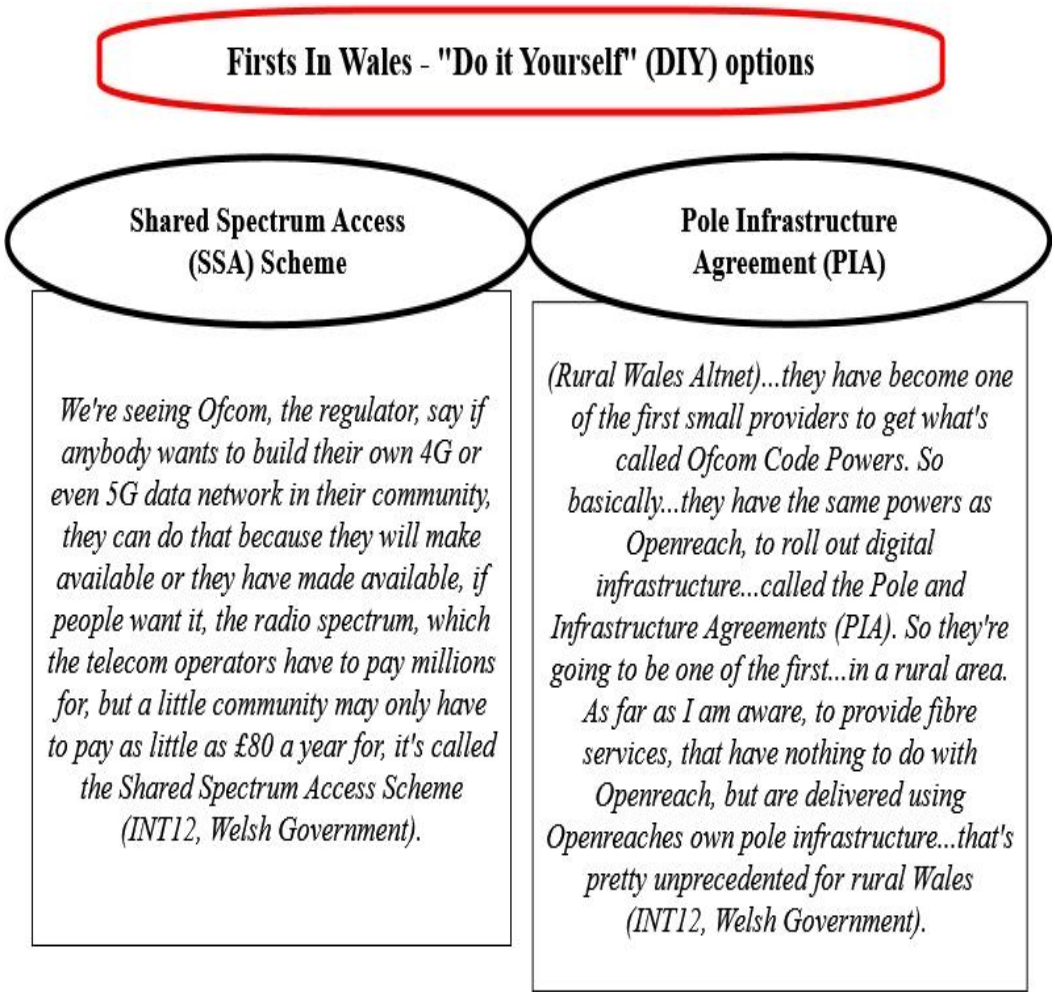


In summary, the value of the EO's human capital (e.g. personal attributes, people skills & tacit knowledge) and SC (e.g. building trust, identifying altruistic volunteers to build rural community relationships & networks, and free word of mouth advertising) are core findings on what capital resources are required (e.g. both financial & non-financial) to answer (RQ1). The mutual learning and cooperative interplay of the "spectrum of human motivations" is a core finding to answer (RQ2). The new and innovative EO relational approach builds trust and is a core finding to answer (RQ1 & 3).

5.4.4 First in Wales – "Do it Yourself" (DIY) options

Another "First in Wales" discovery is the new Ofcom Code Powers to provide Shared Spectrum Access (SSA) and Pole Infrastructure Access (PIA) for local rural communities to "do it themselves" (DIY) (Figure 5.18).

Figure 5.18 First in Wales - Do it Yourself (DIY) options - quotation map



These new Ofcom powers open up the DIY options for rural communities who either do not have EOs or who are not getting anywhere with commercial suppliers. This option allows them to create a network for the community, provided you have the right human, social and financial capital in place (e.g. IT skills, trust & relationships in the community for demand aggregation, communication & support, and the financial capital to build and sustain the network). Nevertheless, it is another new "first" in Wales to bridge the final few and hard to reach gap.

5.4.5 Summary of Welsh Governmental Interviews (RQ1, 2 & 3)

In summary, there are five emergent themes and various surprises evolving from the governmental interviews which follow on from the observation summary (Section 5.3.2). The first theme is the "First in Wales" proactive initiatives (RQ3) focusing on reaching the final 95k through local authority-level and rural community engagement.

The second theme is the value of HC for productivity (RQ1) in reaching the final 95k (e.g. the personal attributes, skills & knowledge available within the Taskforce, PCC & EO initiatives). The personal attributes (qualities) contributing to HC productivity to reach the final 95k include driven, dynamic, enthusiasm, proactivity and tenacity. Skills (abilities) contributing to productivity include leadership, empowerment, people & soft skills, strategy and vision. Knowledge (information about, understanding of) that contributes to productivity includes IT, local tacit knowledge and the spectrum of human behaviour (e.g. altruism).

The third theme is the value of SC for collective action (e.g. trust, relationships & networks) (RQ1). Trust is key when working with rural communities and to engage local action. Relationships and stakeholder management are critical in getting things done. Networks and centralised hubs, repositories and roles (e.g. Taskforce & EOs) to share best practice, lessons learned and knowledge share (RQ2). Mediators & knowledge brokers (IM) are valuable assets within the networks (RQ1&2).

The fourth theme is SFC opportunities and potential local authority interventions (RQ1, 2 &3). For example, the dissemination of the £80m clawback funding, the £10 new community fund, DIIF, DPS, £2m PCC gap funding, SBCD digital infrastructure funding, 70% take up rates to spur investment and the Wall of Money from private investors.

The fifth theme is the complexities of the full fibre network and will be discussed further in (Section 5.10.2). However, barrier busting knowledge share, flexibility in timebound contracts and stranded asset resolution can be resolved at the local authority-level if the right HC, SC and SFC are in place (RQ1 &2).

In summary, the key themes identified is the local authority-level to resolve the final 95k. The value of HC, SC and SFC available within the governmental supply

ecosystem is substantial and will be discussed further in the local-level analysis (Chapter Six). Potential intervention areas will be discussed in (Chapter Seven).

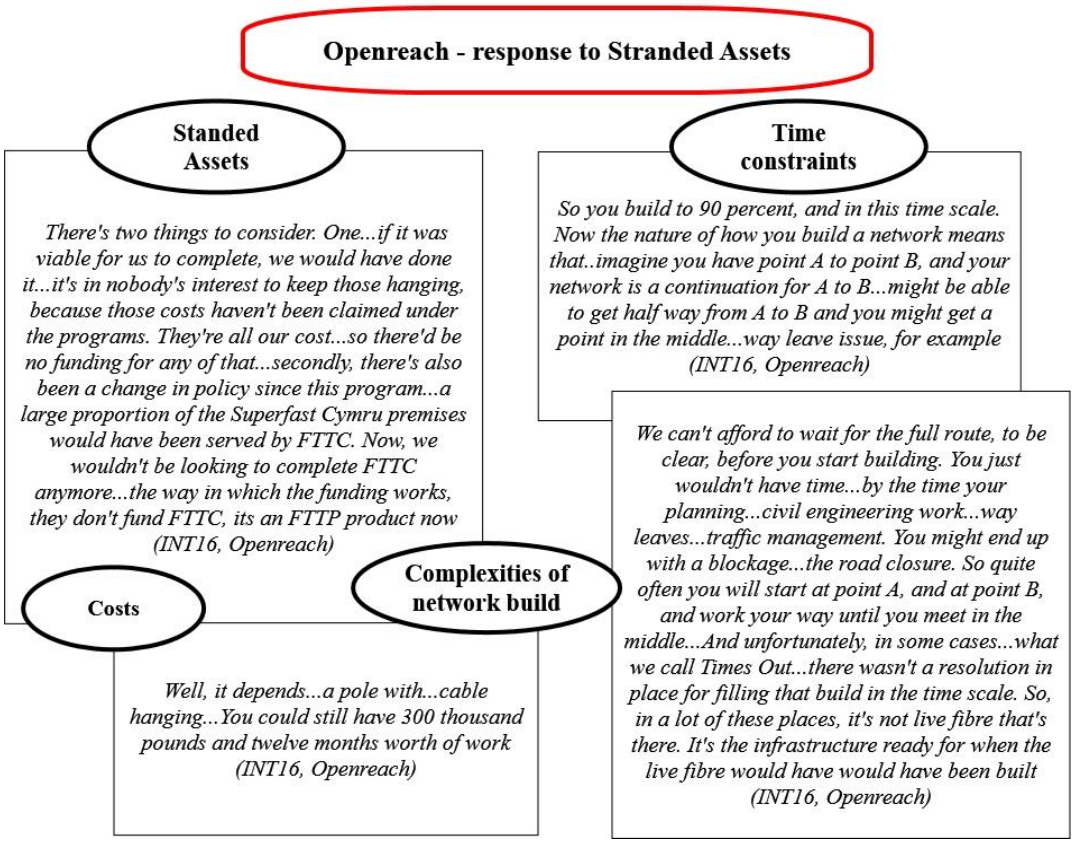
5.5 Commercial supplier interviews – New barriers

Openreach and Altnets are the commercial suppliers tasked with the delivery of "full fibre & 5G". The financial capital is technically available, but not all commercial suppliers have been able to avail themselves of securing the bid (refer to Section 1.4 and Lee Waters AM stating £millions of funding left on the table because of lack of bids). Outside of financial capital negotiations, are the complexities relating to contractual issues (e.g. time constraints) and the "barrier busting" challenges facing all commercial suppliers (DCMS, 2017, n.d-a).

5.5.1 Complexities - Stranded assets, time constraints, local authority-level

During one of the interviews with Openreach (INT16) this researcher asked about the stranded assets and other challenges facing Openreach from delivering to the final 95k. The following quotation maps detail the responses (Figure 5.19)

Figure 5.19 Openreach - stranded assets, time, costs - quotation map

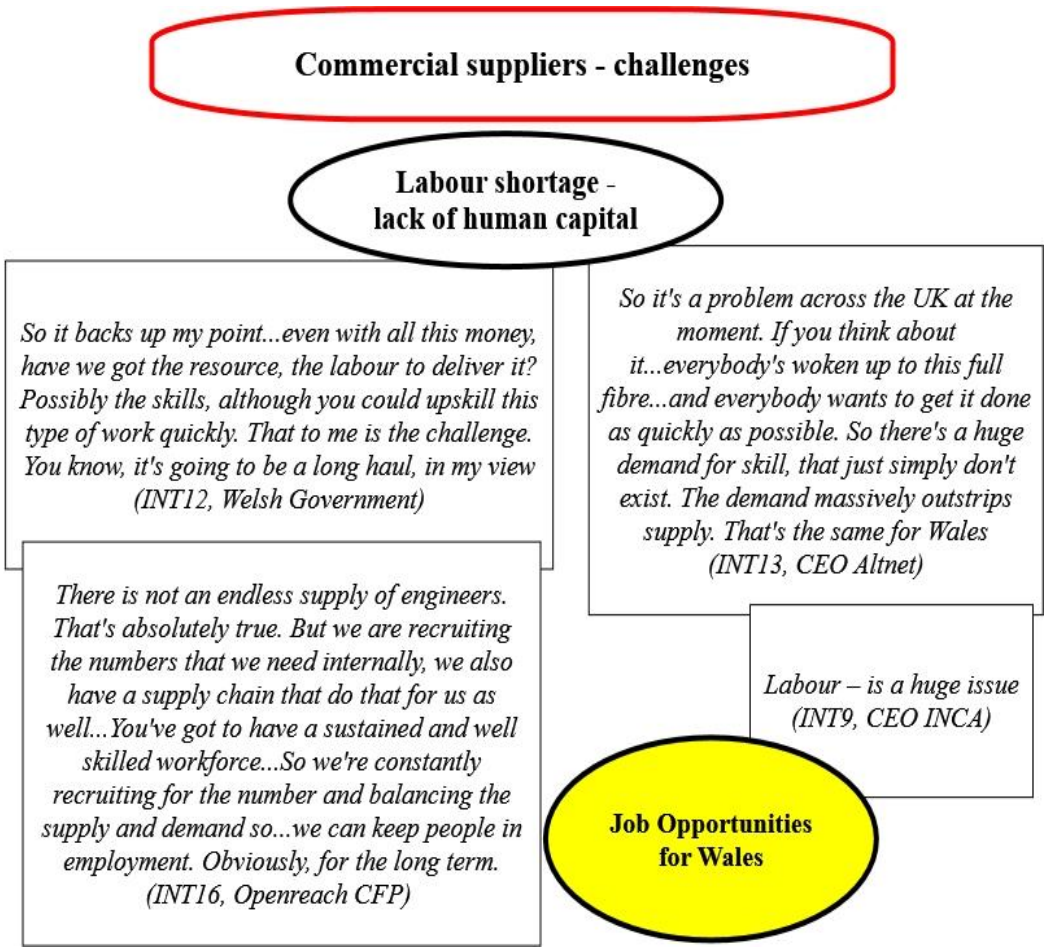


In summary, commercial suppliers are bound by contractual *time constraints* which can be beyond their control. The planning and coordination with local authorities to organise civil engineering works can cause protracted delays if the coordination of "barrier busting" challenges are not overcome (e.g. waiting for way leave access or traffic management delays). Regardless, if the cabling appears to be stranded, the costs to enable these assets is still to be determined. Thus, the understanding (knowledge) of the complexities of the network build is a significant finding of this research and will be discussed further in (Section 5.10.2). In addition, the potential intervention area for improved collaboration opportunities will be discussed (Chapter Seven).

5.5.2 Lack of human capital – Labour shortage (RQ1)

Another critical finding is almost all of the supplier interviewees warned about a labour shortage which could curtail the deployment of full fibre (INT9, 10, 12 & 13). The finding is detailed below in the quotation map (Figure 5.20).

Figure 5.20 Commercial - lack of HC - labour shortage – quotation map



In summary, the commercial suppliers face various challenges, including *complexities of building network*, *labour shortages* (lack of HC) because demand is outstripping supply and *time-bound* contractual issues (Section 3.5 & 3.6).

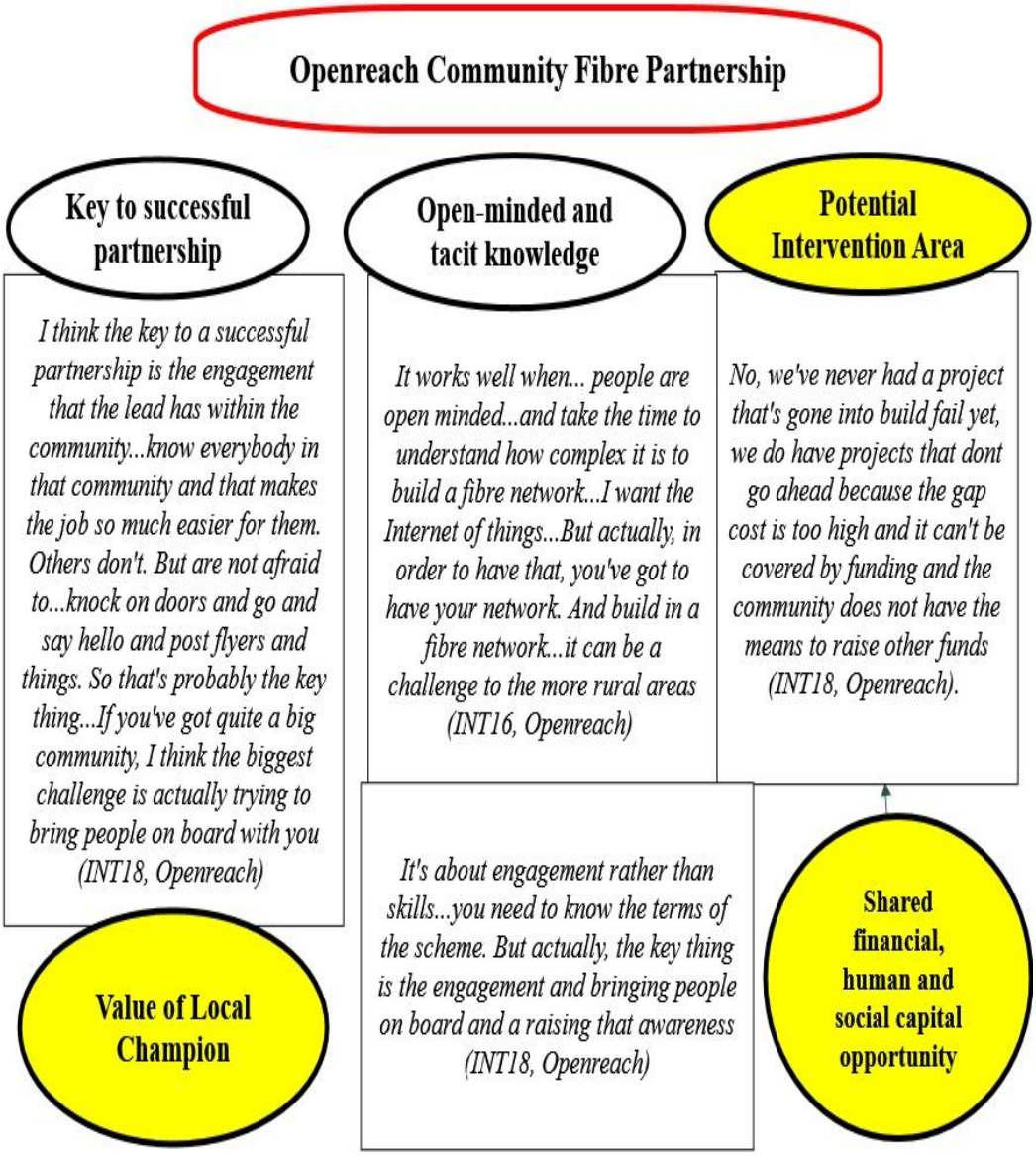
5.6 Commercial supplier interviews – New opportunities

Despite the challenges within the supplier ecosystem, there are equally numerous opportunities emerging. The following section details these opportunities and how various supplier partnerships, collaboration and HC development can benefit all parties to reach the final 95k in Wales.

5.6.1 Openreach CFPs – Benefits of HC & SC (RQ1, 2 & 3)

There were criticisms of Openreach's Community Fibre Partnerships (CFP) in Wales (INT1, LDC SV-A), but within the past year (2019/2020) there is a new strategy to improve the situation. The CFP program should be an exemplar of HC productivity & SC collective action, but the gap costs and onus on the rural communities to organise legal entities to contract with Openreach proved too onerous in certain cases (Section 3.5, B4GAL and Netherlands case studies). Nevertheless, the CFP in Wales is being re-organised and Openreach is hiring Rural Engagement Officers (REO) to focus on reaching the final 95k. Interviews with (INT18, Openreach) revealed the value of HC & SC when working with rural communities. These findings echo those found in previous rural broadband studies (Section 3.5) and summarised in the following quotation map (Figure 5.21).

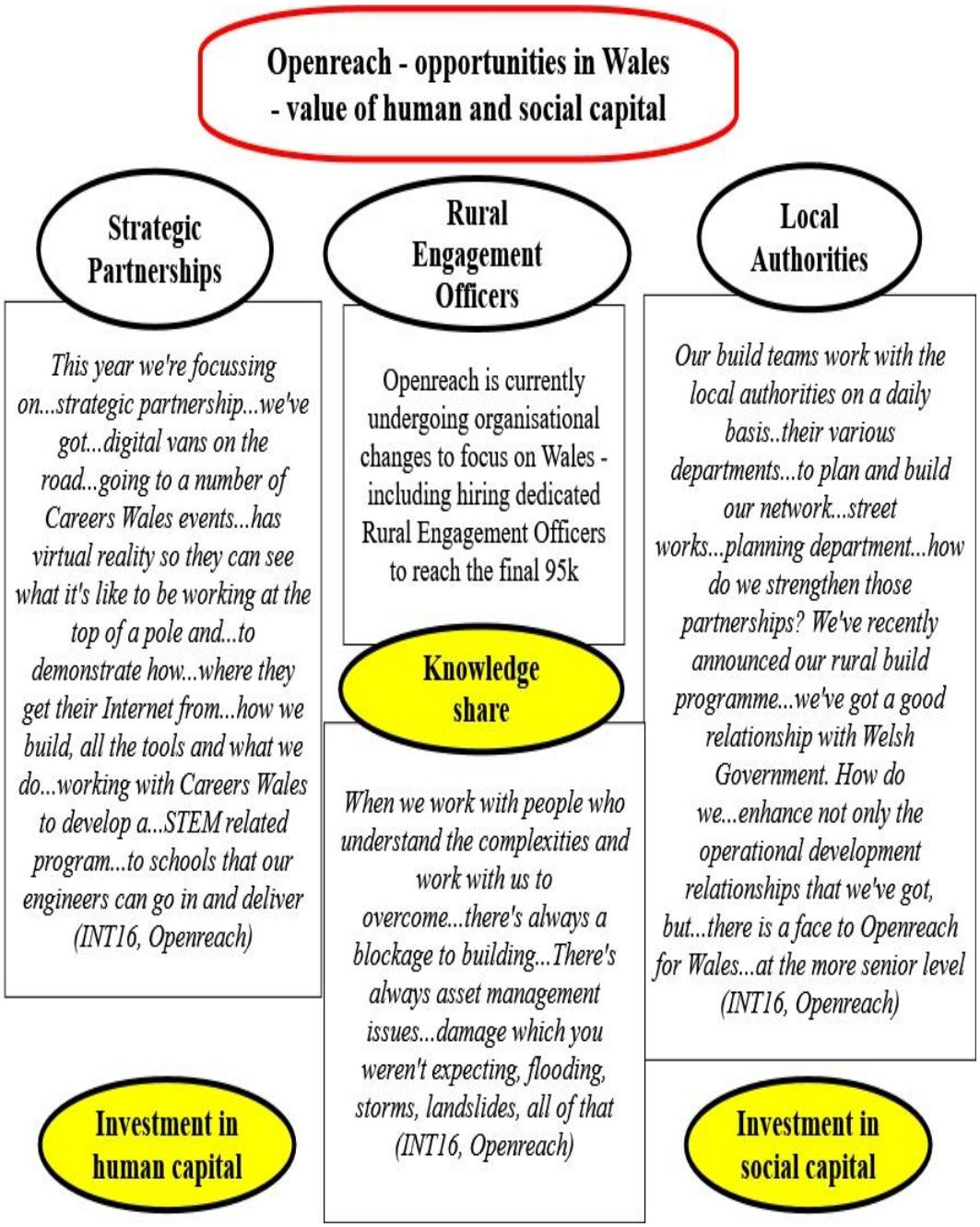
Figure 5.21 Openreach CFP - value of HC & SC - quotation map



5.6.2 Firsts in Wales – Openreach improvements in Wales (RQ1, 2 & 3)

Openreach's improved focus on Wales aims to develop strategic partnerships, hire REOs, and strengthen their working relationship with local authorities. Openreach (INT16) has a good relationship with the Welsh Government (INT15). Openreach hired a Director of Partnership in 2019 to facilitate developing these relationships. The job post is not a technical role, but one similar to the PCC EO strategy by hiring "people & soft skills" (HC) versus technical expertise to bridge the gaps between Openreach and stakeholder relationship management (SC) (INT16). A snapshot of these initiatives is revealed in the quotation map (Figure 5.22).

Figure 5.22 Openreach - opportunities in Wales - quotation map (RQ1, 2 & 3)



In summary, Openreach is developing its HC & SC in Wales through *strategic partnerships* (e.g. Career Wales & engineer training schools*), new HC & SC capital roles* (e.g. Director of Partnerships & REOs) and strengthening relationships with *local authorities.*

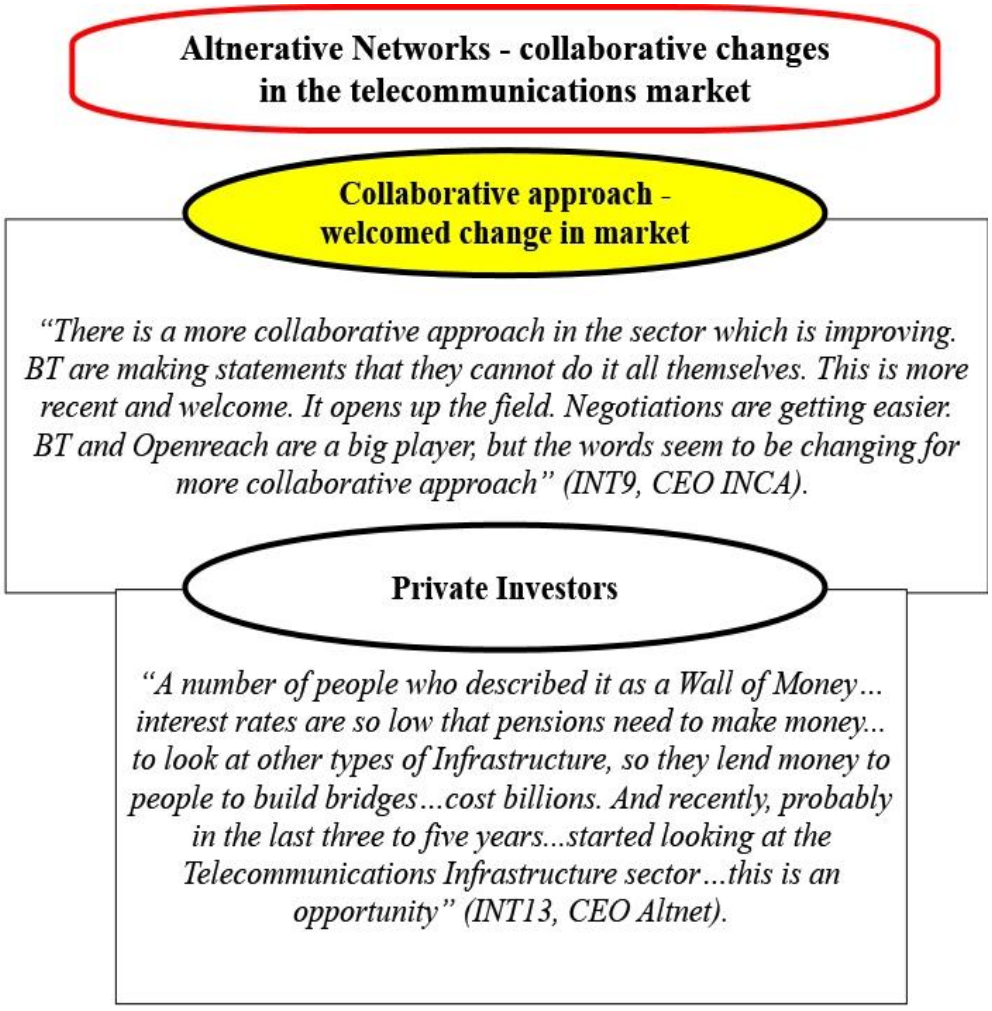
5.6.3 Altnet opportunities – Collaborative approach (RQ2)

A number of positive reinforcements have occurred recently within the sector which are notable. One is the recognition by the Altnets that Openreach is becoming more collaborative (INT9, CEO INCA). As the interviewee stated the proof will be in the output, but there is a recognisable change that Openreach and the UK Government, through the DPS, are listening and responding to improved collaboration within the telecommunications sector to reach the final few.

5.6.4 Improved social capital (SC) - Collaborative approach (RQ1 & 2)

The significant findings for more collaborative approaches and new private investment are summarised in (Figure 5.23). Potential collaboration and intervention opportunities will be discussed further in (Chapter Six & Seven).

Figure 5.23 Altnets – improved social capital – quotation map



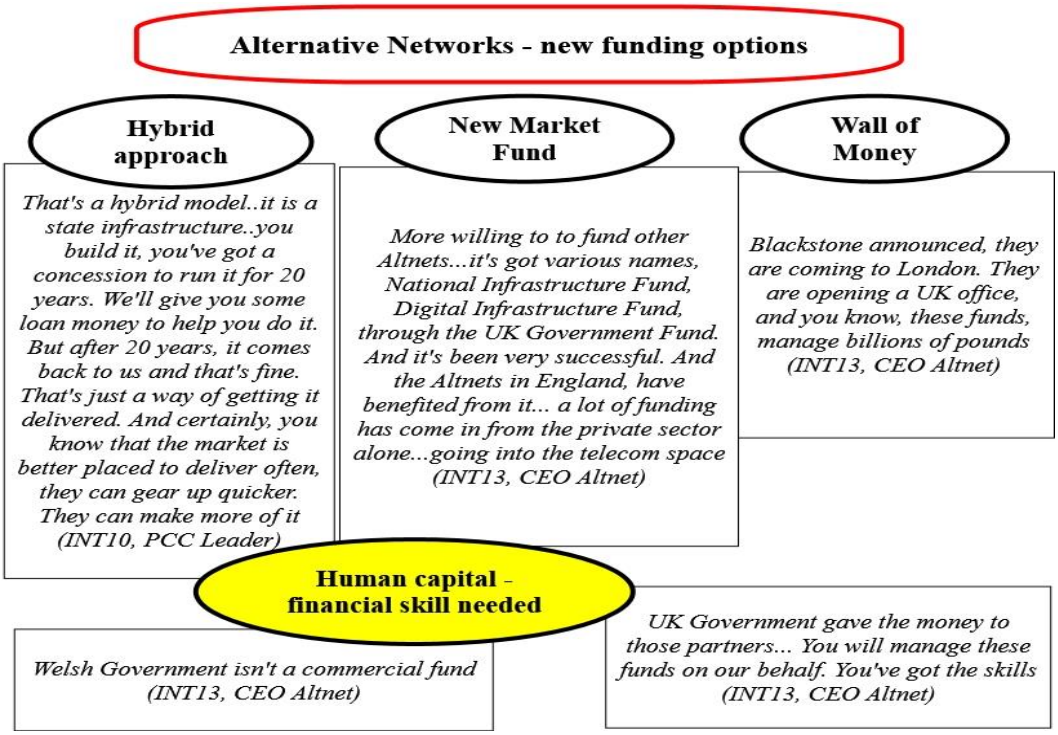
5.6.5 Shared financial capital (SFC) opportunities – "Wall of Money" (RQ1)

The other significant finding which was corroborated at the INCA Conference (May 24, 2019) when another Altnet CEO described the "Wall of Money" coming into the UK to fund digital infrastructure. Major investment firms, such as Blackstone who manage £billions in private financial capital, are focusing on the fourth utility as described above. These major investment firms recognise that digital infrastructure is vital for the next wave of the digital revolution and Industry 4.0, and Altnets are a part of it. Provided they have robust business plans. This assertion was validated by PCC Leader (INT10) who advised Pembrokeshire is considering investment in building duct infrastructure within the county and will consider options on how to structure the funding.

5.6.6 New options – Welsh Government Investment Fund (RQ1 & 3)

As described in the observations (Section 5.2.1) during the Welsh Government Funding Event, another Altnet CEO asked the question if Wales will follow the Digital Infrastructure Investment Fund (DIIF) options that England instituted. If the Welsh Assembly (WA) decides to create a new market fund, this will add another stream to the "shared financial capital ecosystem". The quotation map below highlights the comments relating to this sector (Figure 5.24).

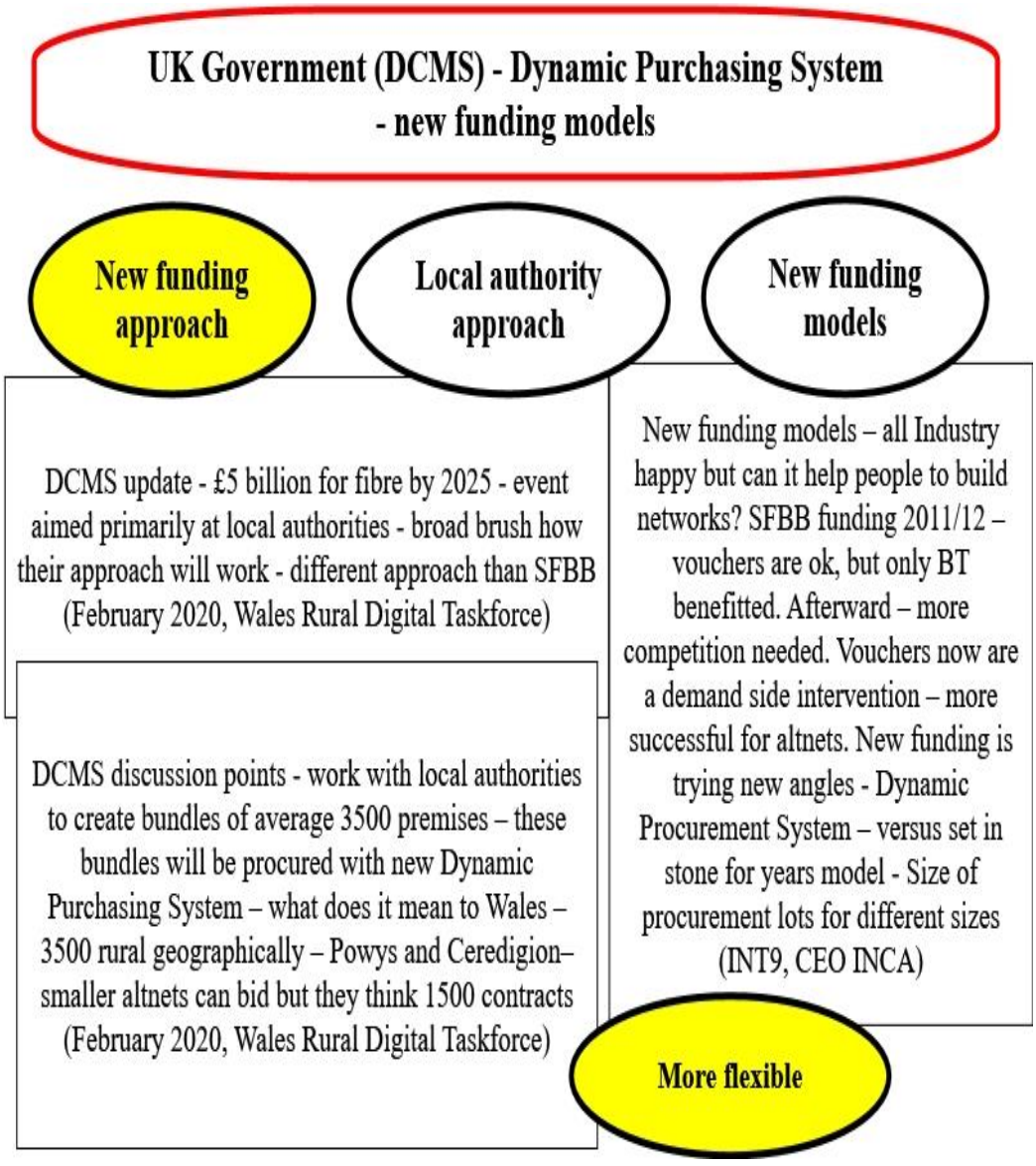
Figure 5.24 Altnets - new funding options - quotation map



5.6.7 Dynamic Purchasing System (DPS) – Local authority-level (RQ1 -3)

The UK Government announced £5 billion to build "full fibre & 5G" networks by 2025 (DCMS, 2018, July 23). A preliminary DCMS briefing, and update was provided at the Taskforce meeting (February 2020). A summary of the new DPS introduced by DCMS is provided in the following quotation map (Figure 5.25).

Figure 5.25 DCMS - Dynamic Purchasing System (DPS) - quotation map



In summary, the UK Government new DPS is aiming to provide more flexibility to help commercial suppliers reach the final 95k. Discussions on how best to distribute and manage this new funding are in progress, but the Altnets welcome more flexible approaches for smaller and bespoke tranches.

5.6.8 Overall summary of exogenous supplier interviews (RQ1, 2 & 3)

The five emergent themes and surprises identified in the observations and governmental interviews (Section 5.2.5 & 5.4.6) compliment the commercial supplier interviews with the exception of the labour shortage (e.g. lack of HC). Openreach has recognised the value of HC productivity (e.g. local champions, IT, people skills & tacit knowledge). The value of SC collective action (e.g. knowledge share, stakeholder relationship management & strategic partnerships) and are investing in new roles to facilitate HC & SC within both ecosystems (e.g. Director of Partnerships & REOs). Altnets welcome the improved collaboration within the telecommunications sector, the Wall of Money from private and a potentially new Welsh Government Infrastructure Fund. The five themes are summarised in following (Table 5.2):

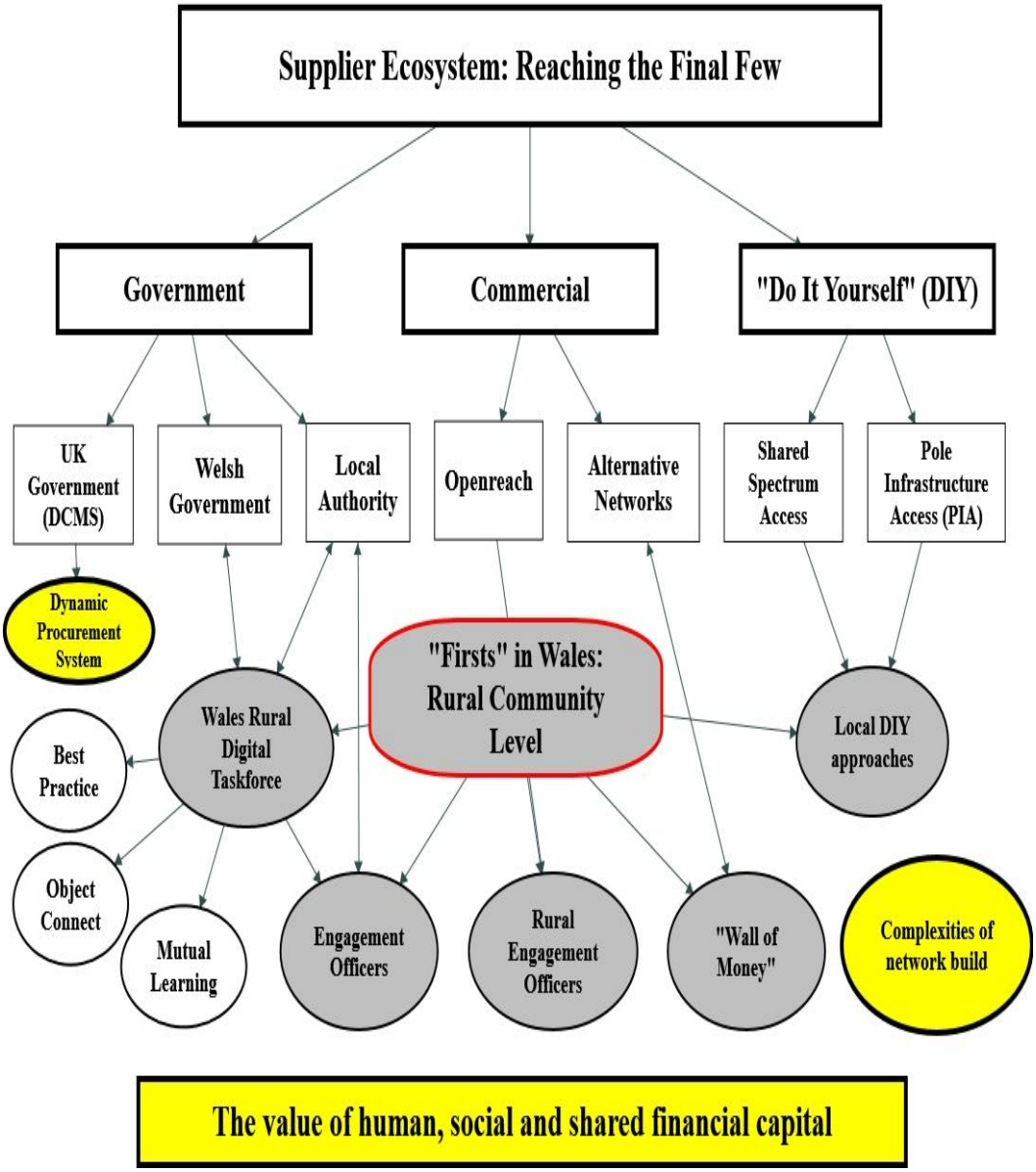
Table 5.2 Summary of five themes identified - nation-level (macro) findings

Number	Theme	Potential Intervention area	RQs
Theme 1	"First in Wales" proactive initiatives – local authority-level & rural community engagement.	Multiple – ecosystem analysis.	3
Theme 2	Value of HC for productivity in reaching the final 95k.	Multiple – ecosystem analysis.	1
Theme 3	Value of SC for collective action to reach the final 95k.	Multiple – ecosystem analysis.	1 & 2
Theme 4	Value of SFC opportunities to reach the final 95k.	Multiple – local authority interventions.	3
Theme 5	Complexities of full fibre network build – stranded assets & timebound contracts.	Multiple – local authority interventions.	1 & 2

**HC (human capital), SC (social capital), EC (environmental capital), SFC (shared financial capital).*

There are multiple opportunities and challenges within the exogenous supplier ecosystem in Wales. There are numerous "First in Wales" proactive initiatives across Welsh Government, local authorities, commercial suppliers and DIY options to provide shared financial capital opportunities, and new human & social capital roles and collaborations (Figure 5.26).

Figure 5.26 Summary of supplier ecosystem findings (RQ1, 2 &3)



In sum, all of these initiatives contribute to answering the RQs. Shared financial and non-financial human & social capital contributions (RQ1), mutual learning and cooperative interplay within the complex ecosystem (RQ2), and the new and innovative approaches are self-evident in the "First in Wales" initiatives (RQ3). Nonetheless, there are barriers, hindrances and obstacles to overcome within the exogenous supplier ecosystem as demand is outstripping supply (lack of HC), and the time-bound contractual challenges and network complexities must be considered. A more detailed and nuanced analysis into the value of HC, SC and SFC, mutual learning and cooperative interplay will be explained in (Chapter Six).

5.7 Interview Findings: Endogenous Demand (Procedure III & VI)

The following endogenous demand interview findings will be presented using vignettes (e.g. to capture the participants unique experiences) and summary findings in quotation maps (Huberman & Miles, 2002; Stake, 1995). As explained in the research context (Section 2.3.6.3) a Microbusiness pilot project (2016) was commissioned by Swansea University i-lab and BT to understand what MBs need and are they interested in UFBB. Overall, the study included 32 participants, but were from a wide range of urban and rural MBs and SMEs and across England and Wales. Nonetheless, this researcher interviewed 16 of the 32 participants, and the raw data from seven of the rural Welsh MBs is worth noting. Interview lengths were between 45-60 minutes. Statistics for the seven rural Welsh MBs interviewed in 2016 are summarised in (Table 5.3):

Table 5.3 Summary of Welsh rural MBs interviewed in 2016

Code	Sector	Years in Business	Legal entity	Turnover	Employees	Internet Use Profile
INTA	IT Consultant (became Mr. G)	10 years	Limited Company	Up to £80k	0-4	Heavy user
INTB	Creative Digital Services – Education & Arts	7 years	Limited Company	Up to $80k	0-4	Heavy user
INTC	Management Consultant	10 years	Limited Company & Sole Trader (coaching)	Up to £80k	0	Medium user
INTD	Digital Media	5 years	Limited Company (digital) & Sole Trader (music)	Up to £80k	0-4	Medium user
INTE	Energy/Solar	40 years	Limited company	Up to £250k	0-4	Heavy user
INTF	Video production/web design	11 years	Limited company	Up to £80k	0	Medium user
INTG	IT Consultant	10 years	Sole trader	Up to £80k	0-4	Heavy user

5.7.1 Microbusiness Pilot (2016) – Findings (Procedure III)

This section presents the findings of rural Internet use from the Microbusiness pilot project (Section 4.8.3). One critical finding is all participants worked from home but had various challenges with connectivity. One of the interview questions is how would they describe their Internet usage profile and what are they currently using the Internet for? Participants selected from four options:

A. *Small users (surfing, online shopping, emails)*
B. *Medium users (surfing, streaming, music, movies, video calls)*
C. *Heavy users (multi-user, streaming, gaming, video calls, homeworkers)*
D. *Super user (working from home, streaming, gaming, video calls)*

As summarised in (Table 5.3), four are heavy users (57%), three are medium users (42%), and are predominantly IT, digital or management consultancies, with the exception of a solar energy company. All the participants do not categorise themselves as "lifestyle" businesses, although they choose to live in a rural community for the healthy lifestyle and preferred option to raise their families. All the participants view themselves as viable businesses that provide income and activity for themselves and their families. This is in contrast to (Galloway & Mochrie, 2005) findings that rural MB are classed as "lifestyle" versus entrepreneurial. Similarly, these findings are related to the next generation user (NGU) OxIS survey (Dutton & Blank, 2014), although these findings show rural MB in Wales want to become NGUs if they can access more reliable SFBB and mobile connections (refer to Section 3.5.2, Table 3.10).

5.7.1.1 Vignettes on Rural MBs experiences in Wales (2016)

The following vignettes act as a baseline of rural Welsh home-working MB experiences and paints a more nuanced picture of what rural MB and homeworkers were experiencing in 2016. These results corroborate (triangulate) the findings from deep rural Internet survey (Section 3.5.2.1, Table 3.10) and the experiences of rural creative MBs (Section 3.5.3.1 & 5.8).

INTA (IT Consultant) – use, experience, and costs

> *INTA lives rurally and has had a lot of problem getting Internet. He has had to use mobile phone masts in garden plus satellite and has consulted for Welsh Government in providing Internet to rural communities. INTA is an IT Consultant so needs the Internet to do business. He needs as much bandwidth as he can get. Has had to get creative to increase bandwidth to his area.*

Vodafone – pays £10/month for 250MB data, because mobile coverage in his area is poor. He uses VOIP (voice over Internet protocol) from office - £3/month for number; free incoming; outgoing calls really cheap 1p minute etc. Very reasonable. With VOIP service rings phone in office and if he picks up with mobile, he is charged. Easy to use. No complaints. For £10/month you can have a virtual business – interactive system – can ring mobile or place on voicemail. BT offers this, but costs more.

INTB (Creative Digital Services) - use, experience, and costs

Her business partner doesn't live locally, so they communicate via Skype for regular business meetings; they use a lot of social media for marketing; they code off-line but need upload online; have to have Internet access; use it for research and on-line/e-learning; upload a lot of artwork; sharing items in Drop Box; videos; animation; library.

Uses BT at home/consumer package – wanted BT Infinity, but not offered in her area. Her home is in rural setting, so she uses the co-working space which has fast broadband. She has to use the office, drives into (nearest city) in order to work more efficiently. However, if she could get faster speeds at home she would work from home. She has children, so at home during holidays etc.

INTC (Management Consultant) - use, experience, and costs

Not massive bandwidth users – pdf, files about 10MB. Emails etc.

He is in rural setting but delighted to have 75Mbps. He is 300 metres from the cabinet. This works really well for him, so cannot complain. Reliability is number one and cost.

EE Consumer package – BT bad experience; most angry he has ever been. Has stayed with EE – good service, reliable, speed, cost. £60 discounted EE landline, broadband, call packages for 75Mbps and 19 upload – incredibly happy. Vodafone mobile £20. He would like UFBB for domestic only – to download HD films in 5 minutes. He would pay extra £5/month for this, but not £20-30.

INTD (Digital Media) – use, experience, and costs

Uses for web content; sending files/music; audio for radio programs; photos; email etc.

For home working – Sky broadband 17Mbps £17/month (includes line rental; great 12-month deal) and Three for mobile £25 unlimited everything – he had deal 5 years ago, can't upgrade otherwise will lose deal. He uses phone to tether all the time.

Has two mobiles – one for corporate work and one for homeworking; he uses a lot for business; tethers instead of the hassle of getting Wi-Fi code; TV job in France – Three mobile has free pick up in Europe; Excellent service; he saves £100s in pounds and loyal customer.

INTE (Solar Energy) – use, experience, and costs

Uses all for work – large files etc.

BT Mobile – not happy – they gave BT a brief on what they wanted when they took them on; wanted outgoing calls; lots of problems; lots of numbers they cannot phone; put a booster onto router to use mobile and it hasn't worked. Cost is higher than first quotes; they were using VOIP previously and transferred calls. This package, BT were 100% certain to save the money but haven't. They will look at other providers because they have spent hours on the phone with BT and are not happy.

INTF (Video Production) – use, experience, and costs

Homeworker - sending files; designer; sends to printers; films short clips on iPhone and uploads to Instagram; does shopping on-line; sells goods on eBay and Amazon; research; doesn't send files every day. 4G or Wi-Fi required – uploads to Facebook, Instagram.

He is using most of these services now with 80Mbps – he uses for home entertainment (downloading from iTunes; uses YouTube); uses Internet for banking, credit cards, motoring, tax etc. and the service is good.

About 6-7 years ago when he was shopping for broadband – BT could only provide standard broadband for £30/month; Orange offered standard broadband for £15.99. Why would he pay double for the same service? EE took over Orange and is still offering good service. BT is reputable brand; secure; but too costly for similar services? He pays £16/month for WIFI; includes phone rental; speed good and unlimited data. He pays £20/month for mobile – he is rural, gets 4G in patches or in town; at home he uses WIFI and on the go 4G.

INTG (IT Consultant) – use, experience, and costs

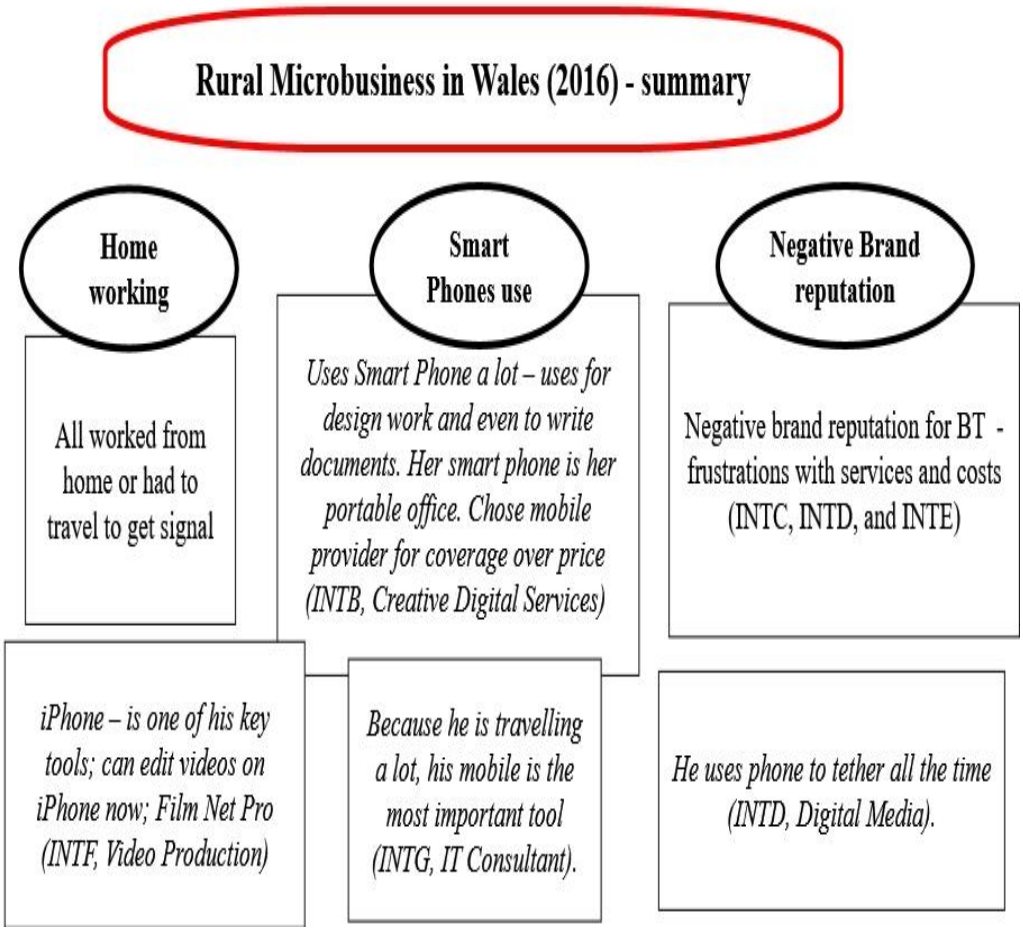
Uses large downloads, upload systems, hosting different things, downloading 100GB. Due to the nature of his job, he needs access to Internet and lots of data. Travels a lot; tethering on his phone; uses Three Mobile and Samsung to do most of his work; often mobile is faster than some of his client's Internet.

Required FAST Internet – his decision is based on speed and cost. He didn't need to host anything, wasn't hosting his own servers, so didn't need a dedicated business line per se. If he was hosting, then he would have a business line, because he would need guaranteed stability.

In summary, the findings for rural MBs in Wales (2016) revealed variable results. All the MBs worked from home or wanted to work from home. For those rural MBs with access to reliable services they were satisfied and could work comfortably from home. For those rural MBs who did not have reliable services, they either had to travel or use their mobile phone to tether services. A primary finding is the use of smart

phones for MBs because of the functionality and access to better speeds. One negative outcome was the costs, lack of services and support some did not receive from BT. Other market competitors were viewed more favourably because of the costs and services, although some wanted BT to offer more affordable services because it is recognised as the national provider. A summary of the core findings is presented in (Figure 5.27).

Figure 5.27 Rural Microbusinesses in Wales (2016) summary findings



5.7.2 Case study investigation (2018) – Demand & skills training (RQ1&2)

During preliminary interviews for case study selection in September and October 2018 (Section 4.7.1) when asked about MB "demand awareness & skills training", both Mr. G and Mr. P stated, it is not enough to offer independent digital skills training, such as social media use. Individuals and MBs are unique in their requirements. Both Mr. G and Mr. P are experts in this field. Mr. G has been a volunteer Business Coach and Mentor for decades. Mr. P understands the value to "educate & demonstrate" when working for the Welsh Government and trying to get rural communities to engage with

the opportunities being presented (RQ2). Both interviewees stated that theory is not enough, and a combined approach is required. For example, MBs need basic business skills (e.g. cash flow, marketing, sales & so forth), plus digital skills (e.g. how to use the software to enhance those basic functions) (RQ1). Both interviewees agreed that bespoke one-to-one engagement has better results. These findings were validated during the RSA Conference (Cardiff University, 2019) with the SFBB Business Exploitation programme results (Section 4.8.2) and the Lancashire report (Knight, 2015) when working with communities to promote SFBB take-up.

In addition, this finding is confirmed (triangulated) in the rural broadband demand-side literature (Section 3.5.2). Basic business skills training coupled with digital skills training is considered a requirement to develop the HC skills & SC knowledge required to fully exploit and expand NGA benefits and services (RQ1 & 2).

In summary, the MBs wanted to work from home, are self-sufficient and self-motivated to get their work done while living in rural Wales. As far as requirement and take-up, all seven rural MBs either have SFBB or want SFBB/UFBB as a reasonable and reliable service. Costs for broadband and mobile depended on access and availability. For those who have it, they are satisfied with the cost and service. For those who do not, they either had to get creative (e.g. if an IT consultant with the skills) or had to drive to nearest town to access fast Internet in an office (RQ1). A “combined approach” is required to merge “demand awareness & skills training” (RQ2). For example, combining basic business skills and digital skills into a bespoke mentorship programme to fully exploit the opportunities being presented with faster broadband access. In response to the COVID19 outbreak, the need for reliable home-working service for rural communities and MBs is now considered critical.

5.8 Splits-Ville case study participants (Procedure VI)

A summary table of the rural case study endogenous demand interviews to date are included in the following (Table 5.4). Data collection includes general information gathering and formal semi-structured interviews. Some interviews were conducted more than once with specific individuals because of their expert knowledge within the specific case study area.

Table 5.4 Summary of endogenous demand case study interviews

Code	Date of Interview	Demand Interviewee	Interview length	Time in community	Purpose
INTA*	Aug 2016	Rural MB	90 mins	13 years	Pilot study interview on rural MB and UFBB
INT1*	Sept 2018	INTA became LDC for Splits-Ville A (2016/2017)	90 mins	15 years	Pre-case study interview
INT1	Oct 2018	LDC, SV-A	90 mins	15 years	Confirm Splits-Ville as case study area
	June 2019	LDC, SV-A	45 mins	16 years	Discuss "full fibre & 5G" RGC funding
	Dec 2019	LDC, SV-A	30 mins	16 years	Discover PCC Engagement Officers in case study area
	Jan 2020	LDC, SV-A	1 x 4 hours	17 years	Interview of pre & post SFBB – Splits-Ville A
INT8	Feb 2020	LDC, SV-B	1 x 3.5 hours	15 years	Interview of pre & post Engagement Officers – Splits-Ville B
INT11	Feb 2020	Ward Councillor	1 x 90 minutes	40 years	Interview of case study Ward challenges
INT17	March 2020	MB – Copy writer	1 x 60 minutes	5 years	Remote rural microbusiness
INT20	May 2020	Farmer – former head of NFU Cymru	1 x 60 minutes	60 years	Remote rural microbusiness

**INTA and INT1 are Mr. G. INT20 interviewed later to understand impact of COVID19.*

The volume of interview data for the endogenous demand interviews is best expressed through a series of vignettes and quotation maps. The following section details the experiences of the LDCs for SV-A and B, as IT experts, and the broadband and mobile experiences over a 15-year plus period. The SV-A vignette describes the journey pre and post SFBB (FTTC) and the value of individual HC (productivity) and SC (collective action) to get the job done. Equally, SV-B explains the pre & post EOs and the on-going project to secure reliable connections for NGA access.

5.8.1 Splits-Ville A (SV-A) – Pre/post SFBB (2016/2017, 2018/2019, 2020)

As explained in (Section 4.8.3), INTA (2016) Microbusiness pilot project interview, also known as Mr. G, became the local digital champion (LDC) for Splits-Ville in 2016/2017 (Section 4.7). It was through the original interviews that the "Splits-Ville" case study was discovered (Section 4.7.1). Since the initial contact, Mr. G acted on behalf of the community to get SFBB (FTTC) installed in SV-A by the end of December 2017 before the Welsh Government funding expired (Section 4.2.1).

5.8.2 Pre-SFBB SV-A (2017) – Rural broadband & mobile services

In 2003, when Mr. G (INT1, LDC SV-A) first moved to the community, the dial-up service speed was 0.5 Mbps. Prior to moving to the area, Mr. G contacted BT, and was promised a 128 Kbps bonded Integrated Services Digital Network (ISDN) service. Mr. G gave the postcode to BT, who advised the service was available but subject to survey. The exchange is four miles, or seven kilometres, line length away from Mr. G's postcode area. Unfortunately, BT failed to provide the ISDN service, so Mr. G ordered a second line for data-only using Public Switched Telephone Network (PSTN) dialup. In 2003, there were no Internet cafés or public facilities to supplement Internet access for this rural community.

In 2013, Three UK (mobile provider) became available in the area. Mr. G worked to get faster Internet speeds by using external antennas and routers to connect to the mobile backhaul but wired into the house. Mr. G achieved 10-15 Mbps speeds for approximately £40/month. Mr. G also used satellite (supplied by Bentley Walker) to attain Internet access. However, the satellite service had limited data usage and was double the cost of mobile at £80/month. Nonetheless, the service was sufficient in speed but restricted in data volume (e.g. if over data limit, costs were £10 per megabyte). Unfortunately, this cost was extortionately expensive, and Mr. G had to actively manage the data limits. Three UK was the same and Mr. G had to call in to stop huge bills if over the data limit. Over time, these services were difficult to manage. Mr. G used the Internet for email and web services only, but no video or "data heavy" services because of the data limitations. Mr. G eventually switched from satellite to Three UK mobile, costing £50/month for minimalistic service/coverage. A summary of services used over the past two decades are:

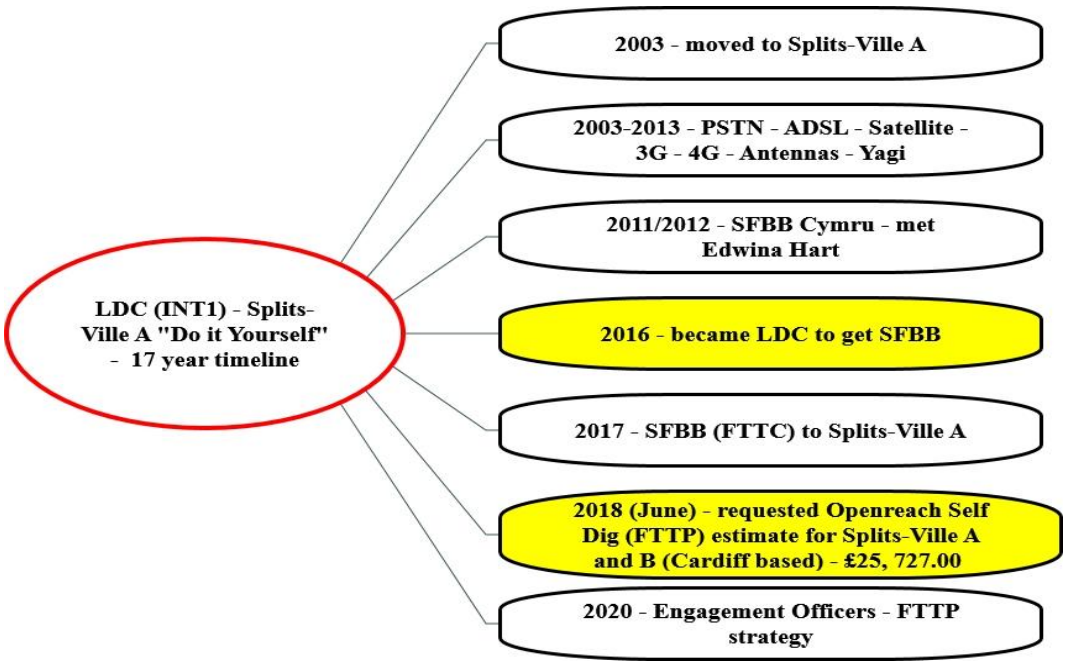
i. PSTN (Dialup) x 2, ADSL (one Mbps) x 2, Satellite (2003-2013)
ii. Three UK (External Antenna) – used because it was 3G (2013)
iii. Upgraded to 4G locally - EE 4G (External Antenna x 2 to get "double speed" – 40Mbps)
iv. SFBB (FTTC) - 70Mbps down, 20Mbps up, unlimited data (December 2017)

5.8.2.1 Negative brand reputation – Rural residents paying cost for poor service

The original service, pre-ADSL service, was PSTN run over copper wire with a later addition of dial-up Internet access. The Asymmetric Digital Subscriber Line (ADSL) was one Mbps, but still charged the same as 40Mbps. Mr. G felt BT was profiteering for being allowed to charge top rate for the poorest of service and rural residents and MBs were being short-changed.

Eventually, Mr. G achieved decent speeds with Three UK and was satisfied until it all fell apart when the company extended coverage to the nearest large town, approximately 10 miles away. This extension meant the company re-mapped the radio network resulting in extremely low speeds in the SV-A location. Regrettably, there was no consultation or resolution from Three UK, despite Mr G making formal complaints to the company. The 17-year "do it yourself" (DIY) timeline for Mr. G (INT1, SV-A) is summarised in (Figure 5.27).

Figure 5.28 LDC (Splits-Ville A) - 17 year - DIY timeline



5.8.2.2 The value of HC & SC – What you know & who you know (RQ1 & 2)

In 2011, MP Edwina Hart came to Pembrokeshire and commissioned Mr. G to write a report about the Welsh Government plans. Four to five suppliers submitted bids to connect the rural areas using copper, whitespace radio spectrum and other technologies. BT won the contract tender; therefore Mr. G knew of the Welsh Government plans in advance of public announcements of SFBB Cymru roll-out.

The question Mr. G wanted to know is when will their exchange be enabled? At that stage they had not done surveys for ducting and so forth which is a major rural cost (see Section 5.10.2 for complexities of network build). This information was not disclosed. Mr. G calculated that 5% of unreached properties is approximately 80k, therefore intervention area funding is required (Section 2.1.4).

5.8.2.3 The lack of SFC – Local authority level (RQ1 & 2)

At the time of Mr. G's investigation to procure SFBB for Splits-Ville, he commented on how difficult it was to ask about funding. The final 5% meant there was not enough funding to go around but talking to individuals became political (e.g. why give one area money over another?). There was no opportunity to present a case for the funds (RQ2). No arena to put a bid or business case forward. No communal process. No fair and transparent process. Hence, this was another reason why Mr. G had to take matters into his own hands and make use of his HC & SC to get the job done (RQ1). This is also a potential intervention area to be discussed in (Chapter Seven).

5.8.2.4 The value of SC – Relationships & network in Wales (RQ1)

Mr. G came to know the Welsh Government IT Expert (Mr. P) at this time, who was responsible for delivering the SFBB Cymru project (Section 2.1.4). Mr. P reported into the Minister and was a technical voice when dealing with the contracts. Mr. G could check SFBB post codes and tried the BT Community Fibre Partnership (CFP) but stated *"it was useless"* (INT 1, LDC SV-A). Apparently, no one in Wales was able to use CFP at this time. Mr. G felt it was just a political department with no action.

Mr. G eventually received a quote from BT and considered how to build a business case. Mr. G contacted Ann Beynon (then Director of BT for Wales) and Ynyr Roberts (BT Infrastructure in Wales). It all came down to "who you know" (RQ1). Mr. G had to work top down versus bottom up because of the frustrations. Mr. G went to Mr. P

(Welsh Government) and Ann Beynon (BT) to get some response to resolve Splits-Ville's rural connectivity problems. BT quoted approximately £100k per mile. The hamlet is at least four miles from exchange and didn't have £400k. Mr. G and Mr. P mapped the area and were able to reduce the cost to £20k.

In summary, it was the value of human & social capital of the LDC (Mr. G) and the forced determination to use his IT skills (HC) and social networking contacts (SC) to get someone to visit their area (RQ1). This process lasted over 18 months. The SFBB (FTTC) connectivity was scheduled for June 2017, but BT arrived on site and tried to place an FTTC cabinet outside of a neighbour's house who objected. This objection delayed the installation until the end of December 2017. Mr. G stated, if BT had continued to involve him in all of these discussions this delay could and should have been avoided (RQ2). It was Mr. G's opinion that BT likes to do things "their way" instead of making full use of the LDC human & social capital within the hamlet. This is also a potential intervention area to be discussed in (Chapter Seven).

5.8.3 Post-SFBB SV-A (2018) – Evidence of four-fold capital benefits

Since the SFBB was installed at the end of December 2017, there have been positive effects on the MBs in the community. Prior to SFBB, the leather making business model relied on customers physically attending workshops in the rural location over a weekend (Section 4.7.1). However, with reliable SFBB the MBs were able to make multiple changes which confirms the four-fold capital benefits identified in Superfast Cornwall (Section 2.3.6.3).

5.8.3.1 Microbusiness business model – Changes & growth (RQ1)

With the new SFBB connection, the leather-making MB is now able to do workshop tutorials and webinars via Skype, and thus changing and enhancing its business model. This has increased the number of customers and provided new access to teaching leather making skills outside of Wales. The MB credits Instagram with providing the vehicle to market a new magazine on leather making and have since mailed over 500 magazines worldwide. This finding is conducive to Teece and Chesbrough business model innovation (Section 3.7.3) and to SFBB Cornwall MB reports on business model innovation as a result of ICT (Section 2.3.6.3).

In addition, the IT Consultant is discovering new ways to connect. Previously, the IT Consultant partnered with an electronics company in Hungary to produce ICT hardware for his farming clientele. When sending the equipment by post, it became lost in the EU. Through Skype, they can now liaise by video without having to send relevant materials through the postal system. A reliable video connection has reduced costs in time, materials, and increased efficiencies and speeds of developing the product through "real-time" iterations versus weeks of waiting for postal to and from the UK and the EU. Additionally, this finding is conducive to Teece and Chesbrough business model innovation (Section 3.7.3) and to SFBB Cornwall economic, efficiency and environmental findings (Section 2.3.6.3).

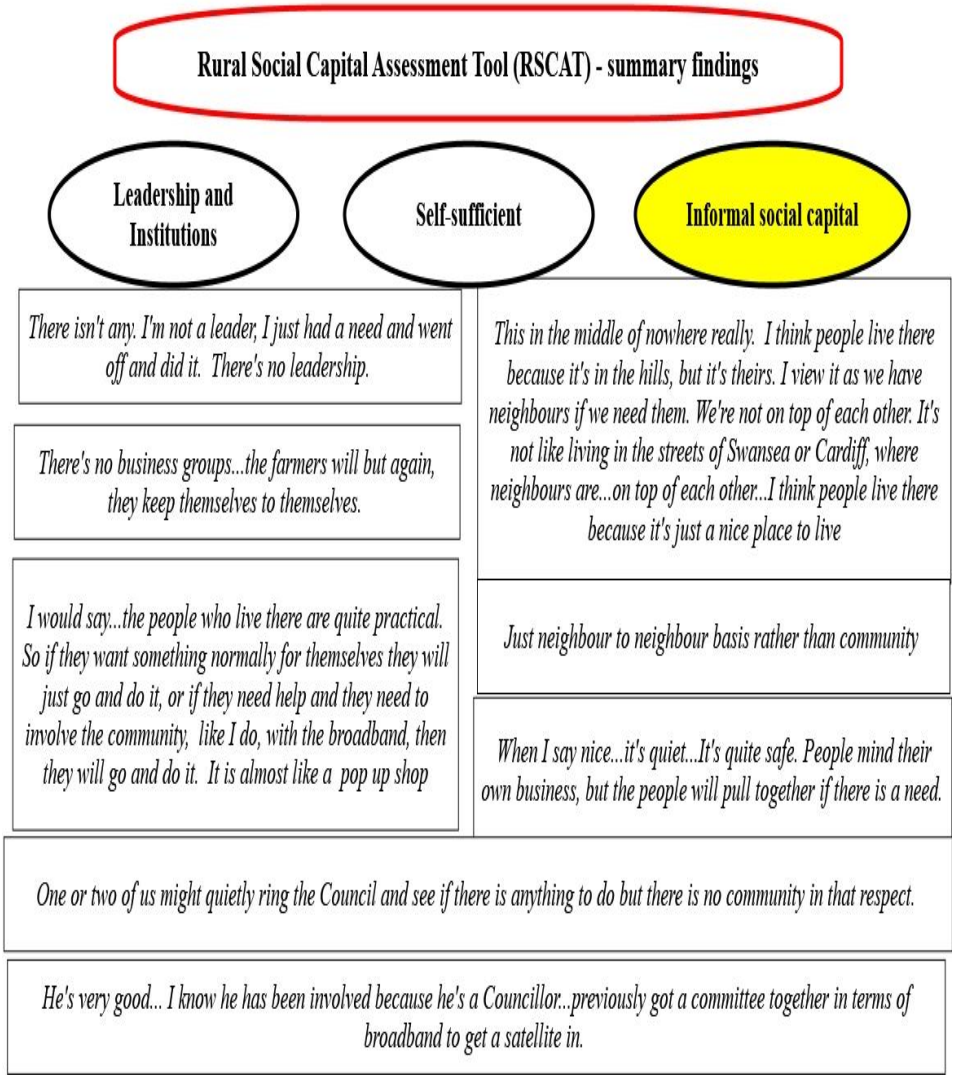
5.8.3.2 Developing HC & SC – Individual (personal) growth (RQ1 & 2)

Another personal benefit has been through the discovery of accessing on-line saxophone lessons (INT1). Through Skype, the rural resident can now access tutorials they could not have imagined before (RQ2). The reliability and speed of SFBB broadband has allowed the rural resident to search the Internet to find saxophone tutors. INT1 found an expert in Oxford who provides lessons through webinars and can now develop his lifelong passion of learning how to play the saxophone. All from the comfort of his home in rural Pembrokeshire. This finding is conducive to Ashmore et al. (2015) and the individual freedom and personal efficiency SFBB affords (Section 3.5.1) to develop human & social capital interests (RQ1).

5.8.4 Rural Social Capital Tool (RSCAT) findings – (RQ1 & 2)

As explained in the methodology chapter (Section 4.10.3) the World Bank SCAT was greatly modified after discussions with Mr. G (LDC, SV-A). The size of the hamlets is small, with approximately 20 properties, therefore there is no formal leadership, institutions and so forth. However, there is a high level of informal social capital where neighbours pitch in to support each other "as & when" it is required (RQ1 & 2). Overall, the LDCs (INT1, SV-A and INT8, SV-B) described the hamlets as "peaceful & courteous", neighbours deal with conflicts amongst themselves. The adjacent village where the school is located provides the centralised hub of activity and the Ward Councillor (INT6) is responsive as and when they need additional support. The RSCAT findings are summarised in the following (INT1, LDC SV-A) quotation map (Figure 5.29).

Figure 5.29 RSCAT (Splits-Ville) summary findings - quotation map



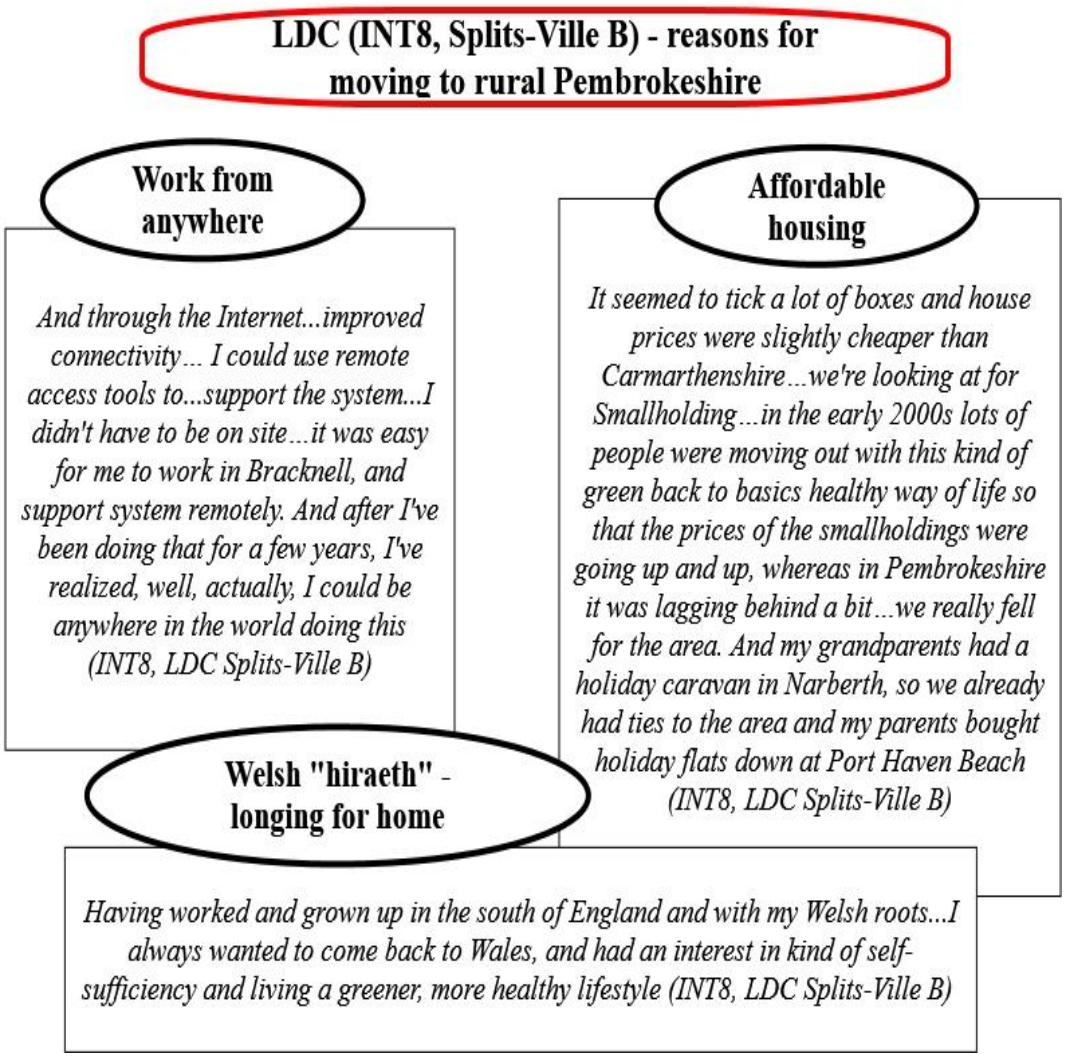
In summary, the rural hamlet does not describe itself as having a formal community leadership but confirms there is a high level of informal social capital and a friendly and courteous neighbourly Community Spirit that helps one another on an "as need" basis (RQ1 & 2). These findings were corroborated by INT8 (LDC, SV-B).

5.8.5 Splits-Ville B (SV-B) - Pre & post Engagement Officers (EOs) (2020)

INT8 is the LDC for SV-B. This is the second half of the community and is typical of the hard-to-reach areas in rural Wales (Section 4.7.1). There are a number of farms, some with young couples and families. There is a horse training business, but they are struggling with connectivity. The family would like to move to the rural location but have to manage the business from their home currently located a few miles away.

INT8 is also an IT Consultant and moved to the area 15 years ago with his wife, because they always wanted to return to Wales and to develop an "eco-friendly" lifestyle. The couple have a high level of human capital. INT8 is an aeronautical engineer, and his wife is a geography graduate. Since moving to SV-B they have had their two children and enjoy the outdoor living and accessibility to the beaches and beauty of Pembrokeshire. The following quotations explain the reasons why INT8 (LDC, SV-B) moved to rural Pembrokeshire (Figure 5.30).

Figure 5.30 LDC (Splits-Ville B) - rural Pembrokeshire - quotation map



The reasons why INT8 (LDC, SV-B) moved to rural Pembrokeshire exemplifies the PCC Leaders (INT10) vision and ambition for the area (e.g. affordable housing, commuter belt, quality of life & so forth) (Section 5.2.3).

5.8.5.1 Commuter belt – Just lacks connectivity (RQ1 &2)

One of the significant findings is the couple discovered the local facilities to be particularly good. They are only 15-20 minutes from the local hospital, although the paediatric services there are apparently going to close. This is a concern for local residents and currently in discussions with the PCC. There is a high level of *informal* social capital, despite living in a deep rural location (validated by Mr. G). Informal social capital means that everyone knows one another but consider themselves as independent and self-sufficient (RQ1). The immediate community does not rely on organised institutional help but support one another informally (RQ2). For example, the local farmers offer to plough the snow or helped the couple when INT8's wife was about to give birth. They have accessibility to the local school, approximately 10-minute drive away, and an adjacent village of 700 residents which has access to Cardiff by train. It is this "commuter-belt" that the couple had not anticipated when they first moved, but the service for his wife when having to work in the capital has been, surprisingly, remarkably good. This finding supports the PCC Leader (INT10) vision and mission for Pembrokeshire (Section 5.3.3).

5.8.5.2 SV-B – "Do it Yourself" (DIY) options – Over 15 years

Prior to the local authority hiring the EOs, INT8 spent years with moderated DIY options. This included at one time putting an old Nokia mobile phone on top of a bamboo pole in an attempt to catch a mobile phone signal from the window of his eldest sons' bedroom. Overtime, INT8 had to settle for satellite connectivity, but it is a difficult service to manage with latency, managing data limits and costs (similar to Mr. G in SV-A).

5.8.5.3 Understanding complexities of network build – Openreach (RQ1 &2)

Openreach had explained the complexities of the network build and INT8 understood it well and states:

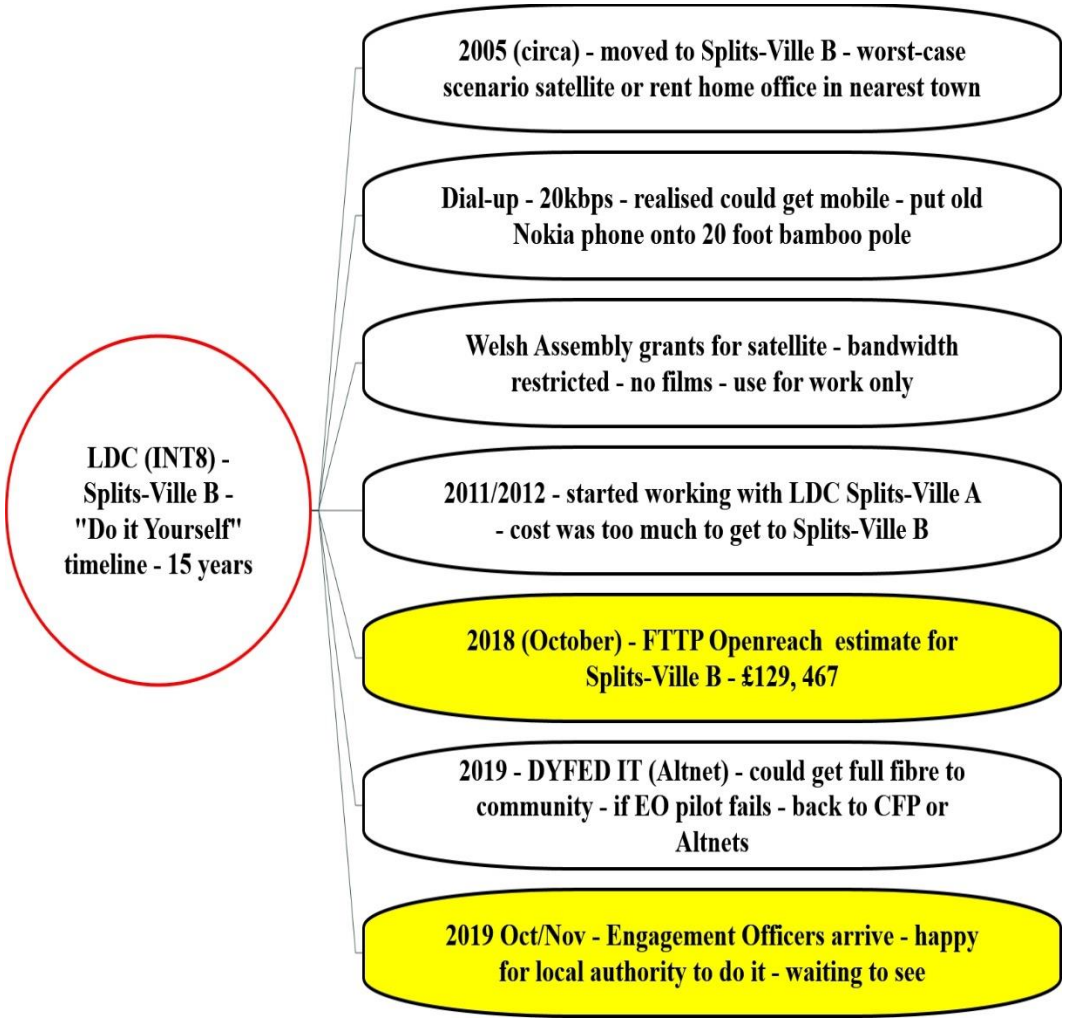
> *It would be like…The poles from here on aren't strong enough…all of this is me making it up, but anecdotally…we've got to run it underground here and we haven't got the wayleaves…to go under this bit or it's got to cross the road. There's enough of a one two-day block issue here for us to down tools. Move on in some way…because you are answering to the government, to the general public. We want X amount percentage of people connected by this date. We've just got to…We're fighting fires…we've got to get all the easy wins…when they spoke to us, it wasn't a sob story. I could totally understand that. That's all they could do. And they were going around mopping up now after they've done the bulk of the work. And it was he who screamed loudest, with the best option money wise, which potentially get a solution and anyone that was not shouting or above a certain threshold wouldn't get it. And their hands were tied…so I could totally understand it (INT8, LDC SV-B).*

In brief, to understand (knowledge gain) the complexities of building NGA networks is considered growth in human capital (RQ1). Working together & sharing information across supply and demand ecosystems is considered growth in social capital (RQ1). This mutual learning and cooperative interplay between LDC, Openreach and local authorities could benefit all parties to get the job done (RQ2). This is a potential intervention area and will be explored further in (Chapter Seven).

5.8.5.4 Engagement Officers (EOs) arrival - November 2019 (RQ1-3)

When the EOs arrived in November 2019, it was a shock. INT8 had already engaged with Openreach CFP and had been approached by an Altnet provider who wanted to help connect them with Rural Gigabit Vouchers. The previous Openreach CFP quotations had been passed onto him by Mr. G after SV-A had been connected with FTTC in 2017. Mr. G (SV-A) wanted to continue working with the Openreach team to get SV-B connected, but all the relevant parties had left (e.g. Mr. G received Openreach self-dig quote in June 2018 for £25,727.00 from Cardiff). When INT8 wanted to discuss the reduced quotation in October 2018, they were then sent to a London representative who gave a different quote of £129,467.00. This lack of continuity from Openreach made it more difficult for INT8 to continue working on behalf of the community. The DIY 15-year timeline is summarised in (Figure 5.31).

Figure 5.31 LDC (Splits-Ville B) - 15 year - DIY timeline



INT8 is pleased to see the PCC taking proactive action to connect the rural areas. INT8 could and would have tried to connect SV-B but found it difficult for a number of reasons. If INT8 had acted for SV-B and the adjacent rural communities discovered he connected his hamlet and not their community, he would feel the "guilt" of not working to provide the service for "everyone". INT8 derives a lot of "non-financial pleasure", similar to Von Hippel's discovery of "free reveal" user innovation motivation (Section 3.7.3), when helping his local community (RQ1 &2). INT8 feels good when people identify him as the "man who helped them with their IT" (explained further in Chapter Six). When the EOs appeared on his doorstep, he thought this was a much better solution because it takes the pressure off him (RQ3). The time it would have taken him as a volunteer to connect his village, but also the on-going commitment of supplier engagement and management.

INT8 expressed a few concerns with the EO pilot scheme. The community hasn't received a lot of communication as to what is happening next. As of February 2020, the PCC had not yet announced the supplier selection and/or when the community might be getting "full fibre" connectivity. This will be discussed further in (Chapter 6). One primary concern is that INT8 could have already connected SV-B with either the Altnet or with Openreach CFP had they been able to reduce the build costs or run a line from SV-A (FTTC) cabinet. By waiting for the PCC EOs to "connect the wider area" this could take another 12 months, but they are waiting to hear. INT8 wants the PCC pilot scheme to be successful, but if there are protracted delays or if the communication wanes, then he might feel the pressure again to get involved. At the moment, he is content to "wait & see", but may call the EOs to keep on top of how the pilot project is progressing. Even though INT8 is not necessarily managing the project, his role as a central community LDC is critical to help bridge the gap between the PCC and SV-B community's anticipation of a much-awaited service.

> *And purely selfishly…it seemed like a lot less work for me if the Engagement Officers…their job to pull everything together because I could see if we did go with (Altnet)…I literally would have to be out at everyone's properties getting everyone to sign up. And it's at that point where people start going 'oh well' and they have all their issues going to do, although we might end up with twelve people signing up for it…for a lot of effort…Might mean that the project doesn't go ahead (INT8, LDC SV-B).*

5.8.6 Splits-Ville – Openreach anomaly

During the LDC interviews (INT1, SV-A; INT8, SV-B) it revealed an Openreach anomaly in the case study area. The technical details of FTTC and FTTH deployment in the UK are complex and beyond the scope of this inquiry. Nonetheless, certain broad explanations can be used to help explain the multitude of complexities telecommunication providers face when rolling out FTTH (Section 5.10.2).

When discussing Mr. G (SV-A) and INT8 (SV-B) experiences of getting SFBB, a bizarre conversation occurred. During the supplier quotation phases, questions were asked to Openreach as to why a fibre line could not be run from an exchange that is geographically closer to SV-B. For illustrative purposes, this telephone exchange is labelled "Y-exchange". The reason given to Mr. G and INT 8 was not 100% clear, but assumptions were made that it had to do with post codes and telephone exchanges, and another assumption was that it was tied to Emergency Services.

To understand why this was the case, an information call with Openreach (INT3) revealed some curious legacy issues which will have an impact on certain final few and hard to reach rural areas. It all depends on geographical location and whether or not the telephone exchange is a Headend (defined below).

Openreach manages an overlaid network which has grown organically over decades. If building full fibre from scratch it would look different, but because of the incremental changes it takes time to phase things out. Over time telephone exchanges were built up from voice only (copper wire connection). If building full fibre from scratch it would not be a telephone exchange. The network doesn't map to telephony network with copper (e.g. example of concentric circles or a hub and spoke network - telephone exchange in the middle with copper telephone lines going out from it).

Openreach explained the anomaly as the following. For technical accuracy, the information notes taken were fed back to Openreach (INT3) for correction. The summary explanation is as follows:

Case study area - Openreach technical anomaly

Openreach legacy challenges and future migrations

Fibre has to connect to a Headend, known as a "Parent" Exchange, which is the interface between the backbone/backhaul to local environment. In rural areas there are several telephone exchanges, but not all are a Headend, known as "Child" Exchanges.

- *A Parent Exchange - is defined as a building where the existing Next Generation Access (NGA) headend equipment is situated (FTTC/FTTP) and is predominantly the Openreach Point off Handover (POH) where Communications Providers (CP) connect to Next Generation Access (NGA) equipment.*

- *A Child Exchange - is defined as a building which is to be vacated by Openreach at some point in the future and currently only houses Business as Usual Ethernet equipment and legacy* ***PSTN/ADSL (copper-based BB), but no NGA presence.***

Exchange routing and bypass
In order to facilitate the eventual vacation of the Child Exchange, all new Spine cables will bypass child exchanges and route directly back to the Parent Exchange without entering the Child Exchange or its cable chamber. At the Parent Exchange the fibres will terminate on an Optical Distribution Frame (ODF) before routing to any NGA or Ethernet terminating equipment. ODFs will not be required in Child Exchanges.

Ethernet demand will be routed back from the Parent Exchange to the Child Exchange, down the same cable, to an Aggregation Node on the Spine route close to the Child Exchange, where a smaller count fibre cable will link to the existing Optical Connection Rack (OCR).

- *This is to ensure sufficient fibre capacity at the Parent Exchange to enable Openreach's long-term strategy of all headend equipment eventually being located at the Parent Exchange, and subsequent closure of Child Exchanges.*

- *There are also exchanges which have a rural layer 2 switch for NGA and so would be classed as a Parent Exchange but are not Points of Handover (PoH).*

- *The POH is a place where Internet Service Providers can connect – any commercial supplier who uses Openreach services connects at POH and then manages the network and services.*

Please refer to Openreach Ghost Plan in (Section 5.10.2.7) for more detailed explanation.

***** *Technical definitions can be found in (Appendix B).*

5.8.6.1 The Splits-Ville case study anomaly

If the fibre and headend are at the telephone exchange, then you have to get your connection from that telephone exchange and cannot cross the postcode border. However, if the local telephone exchange *is not a headend*, then you can cross the postcode border to get a connection. The backbone system is not based on the same topography. The future plan for the fibre network dictates where your headend is located, as the build is now being completed to a future template not the traditional telephone exchange areas.

For example, there may be ABCDE telephone exchanges, but only F is the headend. In this case, ABCDE can cross postcode borders to connect to F. In the case of SV-A and B, they are administratively tied to "X-exchange" (parent exchange). Since "X-exchange" is a headend, then SV-B *cannot* cross the postcode border to "Y-exchange" despite it being geographically closer, because "Y-exchange" is also a headend (parent exchange). It all has to do with Backend or Administrative System and Planning Protocols. If you can retain the build within the exchange area it is easier for administration. However, to clarify, it has nothing to do with emergency services. Telephony calls carry a Calling Line Identity (CLI), and this would be used to help emergency services.

Openreach is restricted. It is managing 30-40 million addresses. If they do not do it, it causes problems to their backbone. There are Unique Premises Reference Number (UPRN) to identify backend, National Address Database (administrative network information), to process orders and to connect services. The back-end services need to line up. It is a Network Record Issue (NRI), for telephony obligations, which makes record keeping easier – at the moment.

By 2025, premises will still have a telephone number, but the analogue telephone will be replaced with Internet Protocol (IP) addresses. Public Switched Telephone Network (PSTN), or the "old copper lines", is planned to be turned off in place of Voice Over Internet Protocol (VOIP), with a number of stages and products, but this takes time to migrate over. Eventually, the plan is to have full fibre and a "wide area network (WAN)" type topology, and these legacy issues will be made redundant (see Appendix B for technical definitions).

5.8.6.2 The Order Process – Computer says "no"

This is where the challenge for SV-B and some rural communities are affected. The "Y-exchange" is in a different telephone exchange area. To place an order for SV-B to connect to "Y-exchange" the system would not compute to get active services.

INT3 (Openreach) explains, in general, how orders are processed.

> "*An order flowing from a customer to an Internet Service Provider (ISP) and then into Openreach has to pass through several systems and at each handover all data and software flags must affirm that all previous stages are completed but at each stage, data is automatically checked to ensure compliance and onward flow".*

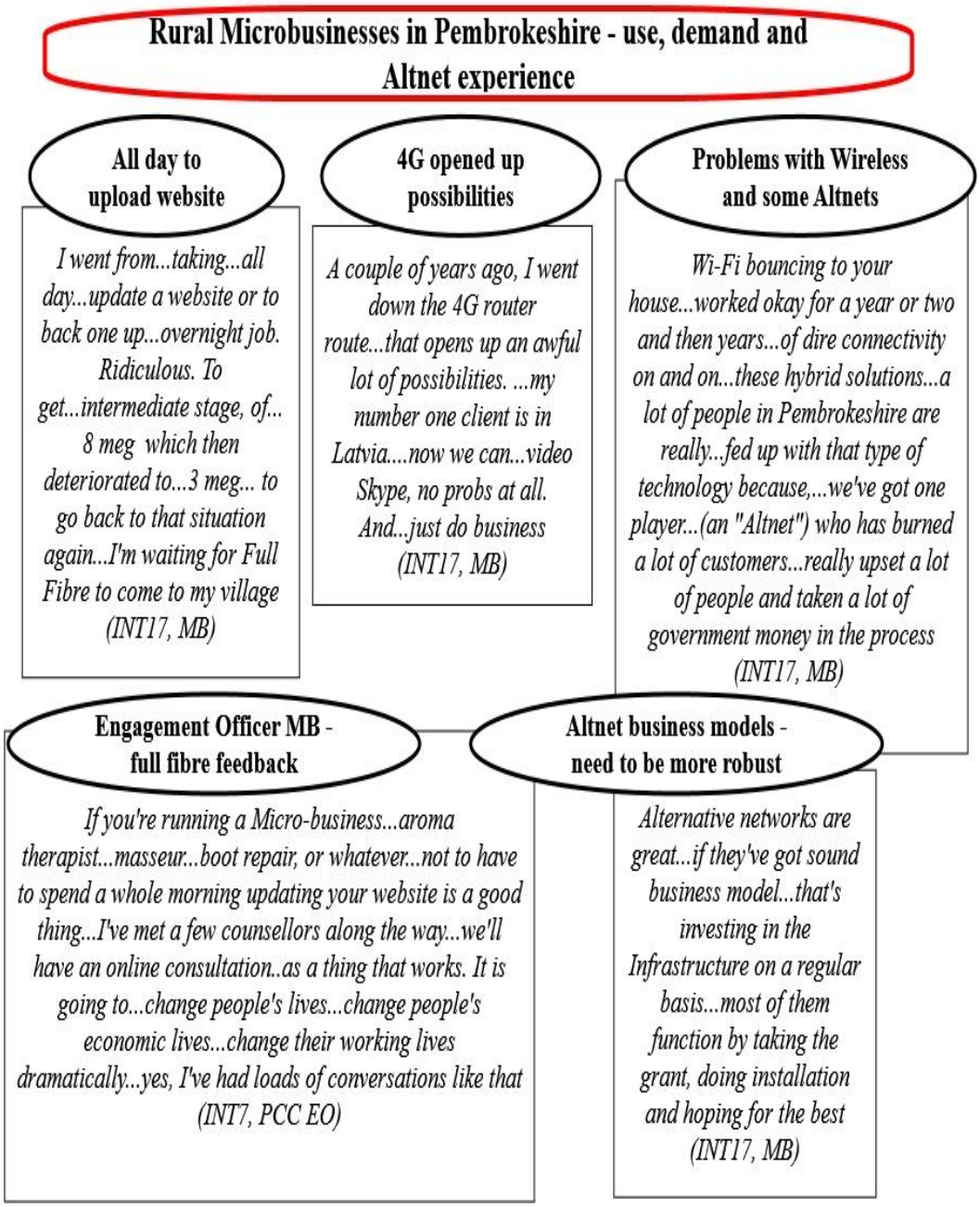
The order systems are configured. There are only a few communities with this dilemma. It would cost £millions to upgrade the system. During the transition period it is not financially feasible to upgrade the backend administrative system to accommodate these anomalies to place an order. At the moment, if the headend is the local exchange you are tied to it.

In summary, there are complicated legacy issues which are beyond the scope of this inquiry. Nevertheless, a more detailed technical summary of the challenges Openreach, Altnets and DIY options are presented in the document analysis (Section 5.10.2).

5.8.7 Rural microbusinesses (MBs) & farmers – Pembrokeshire

Additional interviews were conducted with MBs within the area who express their frustrations with poor connectivity, the challenges with Altnets and the absolute need for reliable services for MBs and farmers to work, particularly in the aftermath of COVID19. The following quotation maps summarise their experiences (Figure 5.32).

Figure 5.32 Rural MBs in Pembrokeshire – experiences - quotation map

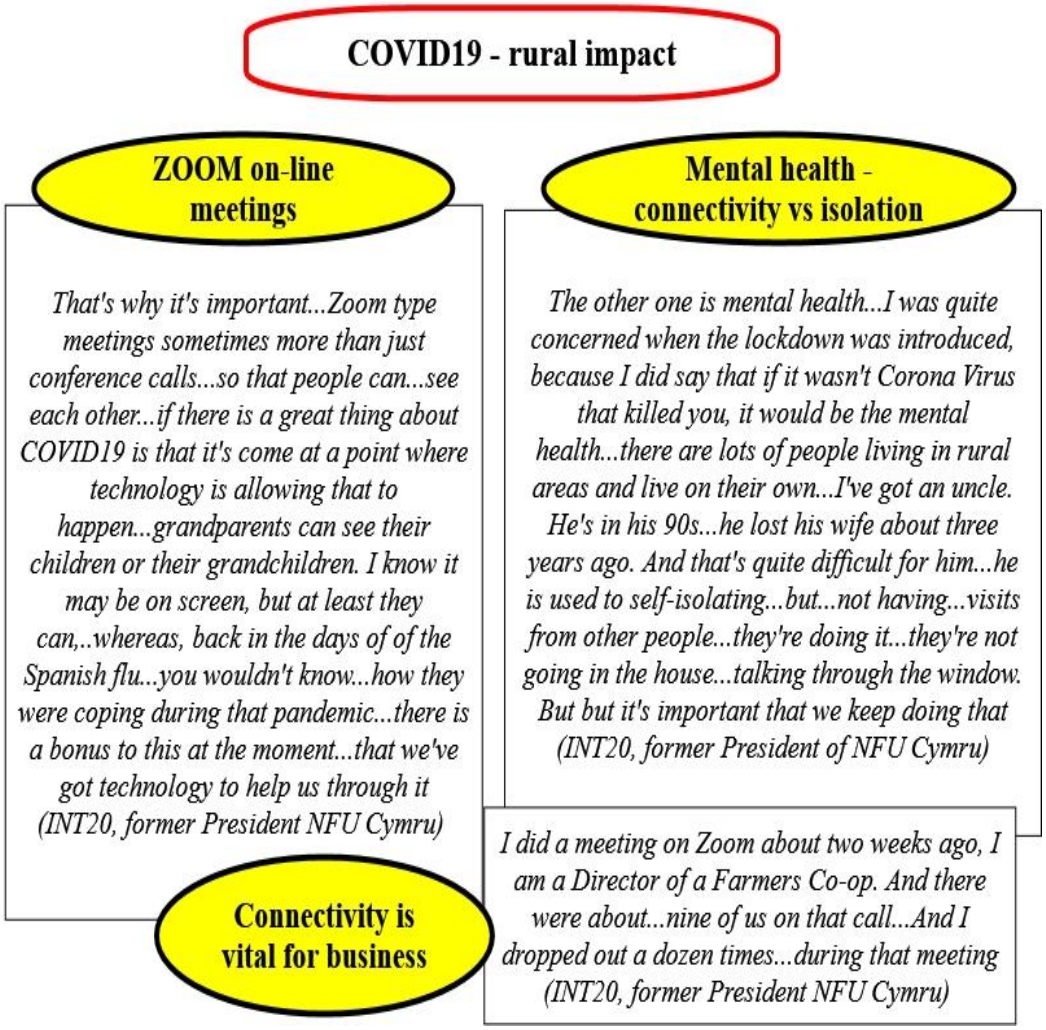


In brief, these findings are validated by SV-A MBs (Section 5.8.1), SFBB Cornwall MB reports (Section 2.3.6.3) and numerous rural creative MBs studies (Section 3.5.3.1).

5.8.8 COVID19 - New driver

The global outbreak of COVID19 happened during the data collection. Most of the interviews were conducted before the lockdown measures were implemented. However, one interview with a former President of National Farmers Union (NFU) Cymru is worth noting. The impact of on-line ZOOM meetings to conduct business, and the emotional and social impacts are summarised in (Figure 5.33).

Figure 5.33 COVID19 - rural impact - quotation map summary



The former President of NFU Cymru and his wife are retired, but active members in the community and chair numerous boards from local and national government, as well as local farmers co-ops, the Women's Institute (WI) and the Young Farmers Organisation (YFO). The reliance on on-line ZOOM meetings and the unreliability of the connection to participate in these vital meetings was constantly undermined

because of intermittent connectivity. The business needs are evidenced throughout the rural MB interviews, but also the emotional and social connectivity needs to stay connected to family and friends during the COVID19 lockdown.

These findings are supported by BBC news articles during COVID19 outbreak and how "abysmal" rural village life is without reliable broadband connections (Williams, 2020, April 22). This resulted in calls for better rural broadband in Wales to support working from home as a result of the outbreak (Evans & Evans, 2020, June 5).

5.8.9 Summary of endogenous demand interviews (RQ1, 2 & 3)

Five inductive themes and surprise anomaly have been identified in the endogenous demand interviews. The first theme is the enforced rural DIY options that were impressed on rural LDCs to find solutions for their communities. The second theme is the unequivocal value of Mr. G's HC & SC which resulted in successful implementation of SFBB (FTTC) for SV-A (RQ1 &2). SFBB resulted in the four-fold capital benefits for MBs in that half of the hamlet. The RSCAT findings revealed the value of informal SC, and the self-reliant and self-sufficient Community Spirit in Splits-Ville (RQ1 & 2). The third theme is the failure of the local authority and Openreach CFP, to provide a centralised hub for rural communities to present a business case for funding and support. The fourth theme is the corroborated experiences of rural MBs across multiple studies and the critical imperative of reliable rural connectivity post-COVID19. The fifth theme is the verification of the complexities of building full fibre networks and the surprise legacy anomalies convoluting the process.

The demand for full fibre and improved connectivity is evidenced through the EOs 70% surprising take-up rate finding, more MBs and homeworkers registering as a result and the word-of-mouth influx of interested demand outside of the PCC pilot project areas (RQ3). Rural MBs experience is no longer acceptable, particularly in light of COVID19. The challenges numerous MBs had with Altnets, BT and Openreach needs to be addressed. Hybrid solutions (e.g. wireless or satellite) are not as reliable as full fibre, and more robust business models are required within the sector to provide adequate investment into the infrastructure. The demand is evident. The supply is now an essential requirement. The five themes identified in the endogenous demand interviews are summarised in the following (Table 5.5).

Table 5.5 Summary of five themes identified - endogenous demand interviews

Number	Theme	Potential Intervention area	RQs
Theme 1	Rural DIY – poor service & cost. Enforced LDC HC & SC to resolve.	Multiple – local authority & CFP support.	1& 2
Theme 2	Value of HC for productivity - LDCs & rural MBs experiences.	Multiple – value of embedded place-based capitals & triangulated results.	1
Theme 3	Value of SC for collective action – RSCAT informal SC & Community Spirit.	Multiple – value of embedded place-based capitals & triangulated results.	1& 2
Theme 4	Centralised Hubs – failure of local authority & Openreach CFPs.	Multiple - No facility to put forward business case for funding.	1-3
Theme 5	Complexities of full fibre network build - Openreach rural anomalies.	Multiple – value of HC, SC, EC and SFC.	1& 2

**DIY (do it yourself), EC (environmental capital), HC (human capital), LDC (local digital champion), RSCAT (Rural Social Capital Assessment Tool), SC (social capital), SFC (shared financial capital).*

5.9 Industry 4.0 - Opportunities & barriers

Only two participants, from both the exogenous supply and the endogenous demand interviewees are familiar with the term Industry 4.0, the rest have never heard of it. Participants are more familiar with terms such as "digital revolution" or the "Internet of Things" (IOT). They are familiar with the concepts of "tele-health" and "tele-working", but Industry 4.0 is not widely known or fully understood. Despite the lack of comprehension, there are numerous opportunities for rural Wales.

5.9.1 Industry 4.0 - Opportunities for rural Wales

One notable opportunity is LoRaWAN to enable the Internet of Things (IOT). LoRaWAN is a media access control (MAC) protocol for wide area networks and "*designed to allow low-powered devices to communicate with Internet-connected applications over long-range wireless connections"* (The Things Network, n.d.). LoRaWAN does not need "full fibre & 5G" to operate. Nonetheless, it is a new field of innovation and can be used to improve farm security (e.g. gates being left opened or a mouse trap in a cheese shed), animal welfare or crop management.

More specifically to Industry 4.0, is the potential data capture from the sensors that can be placed in various places around the farm or across remote rural areas (e.g. examples of agricultural technology (or *Agri-tech*) opportunities). The sensors may not need full fibre connectivity *yet* for data capture, but they will need faster and

reliable broadband speeds for data analysis (e.g. hundreds of sensory data will need to be captured, analysed and new products & services such as dashboards & control centres will need to be established).

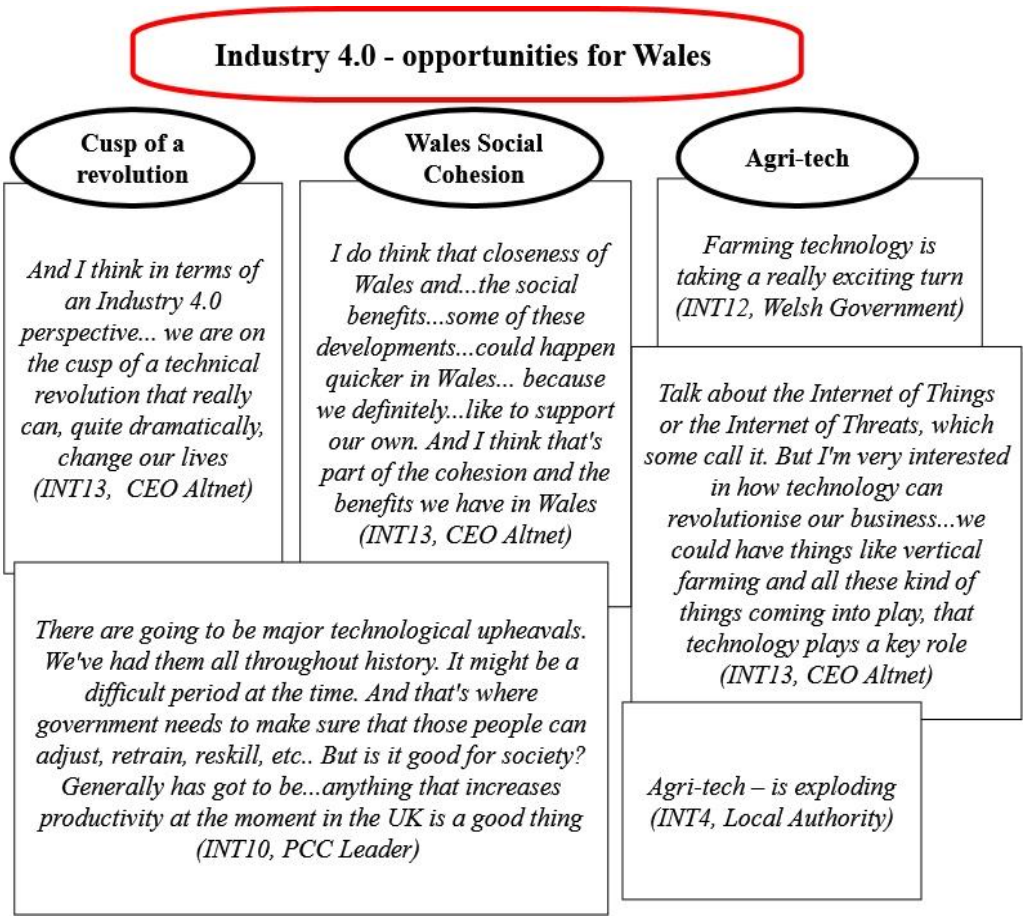
5.9.2 Examples of Agri-tech opportunities in Wales

The Welsh Government currently has 18 demonstrative farms across Wales through the Farm Connect program. As summarised by the Welsh Government:

> *For example…farms will be able to install sensors on their gates to tell them if a gate is being left open…maybe open the gate to steal the sheep or…a walker going through the fields, left the gates open…maybe mixing up with neighbouring sheep or causing a biosecurity hazard or…a sensor on the quad bike in the shed…farm security…in terms of application…the general management of the farm….if you put temperature sensor on the field…to be applied with fertilizer…that kind of basic information means that the farmer potentially will use less fertilizer, meaning less pollution and less cost to the farmer (INT12, Welsh Government).*

The following quotation map expresses some of the optimism surrounding Industry 4.0 and the opportunities for Wales (Figure 5.34).

Figure 5.34 Industry 4.0 - opportunities for Wales - quotation map



5.10 Document Analysis: Findings from Procedures III-VI (Tier Three)

Additional document analysis became apparent during interviews (e.g. LDCs, PCC and Openreach). The additional documents (Tier Three) for analysis are provided in the following (Table 5.6)

Table 5.6 Summary of document analysis (Tier Three) – from interviews

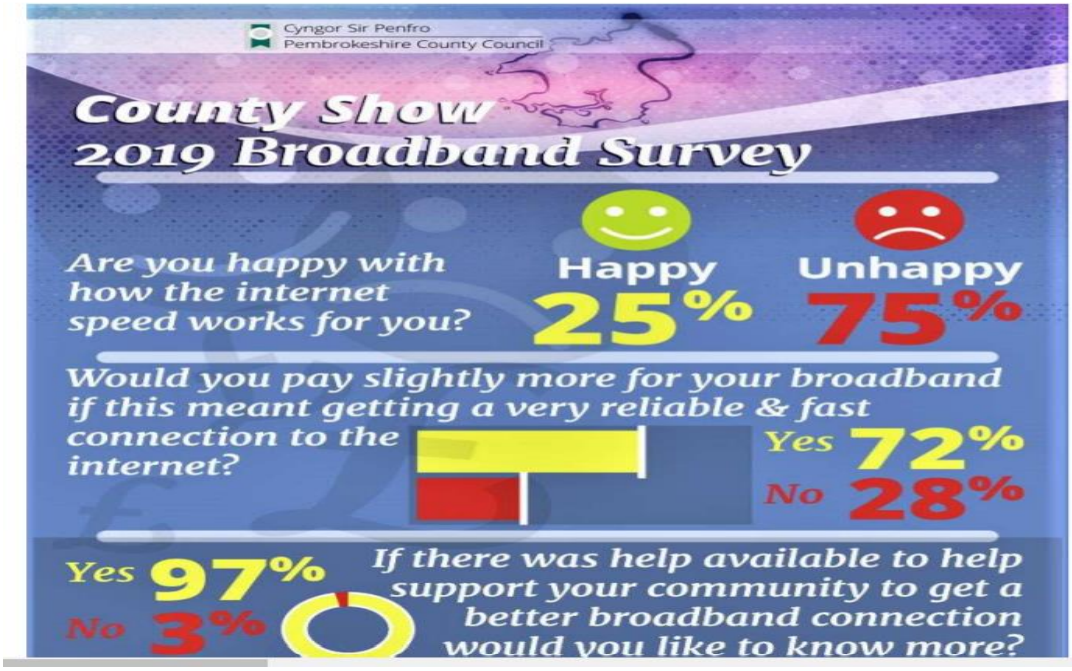
Data Source	Event	Document	Relevance	Reference
Exogenous Supply interviews	PCC Digital Pembrokeshire	Website	Understanding brand strategy	(Digital Pembrokeshire, 2019)
		Twitter Feeds		(Digital Pembs, 2019b)
		Facebook Page		(Digital Pembs, 2019a)
		Survey		(Digital Pembs, 2019b)
		Maps		(Digital Pembrokeshire, 2019)
	Openreach anomaly	Ghost Plan	Understanding network build	(Openreach, 2018)
	Openreach (INT16): suggested report for Environmental capital questions (October 2019)	Full Fibre Impact Report (CeBR)	Working from home carbon emission reduction (EC) & city de-urbanisation.	(CeBR, 2019)
Document Analysis	Openreach: News & Opinion articles (January 2020)	Full Fibre News - cutting carbon footprint	Environmental Capital	(Openreach, 2020, January 20)
	Openreach documentation from SV-A and B	FTTP community quotations and route map	Understanding how Openreach quotes & planned case study area	Documents supplied by (INT8, LDC SV-B)
	Complexity of network build – following interviews	YouTube instructional videos	To understand technical detail/challenges of network build	(see below, Table 5.6)

Openreach: Video (January 2020)	Welsh Assembly Member visits FTTP rollout	Openreach technical challenges - demonstration	(Openreach, 2020)
Openreach: updates/UFBB briefings (January 2020)	NGA – 227 new FTTP locations including rural	Updated UFBB rollout coverage - rural	(Openreach, 2020, January 27)
To understand 5G concerns from demand interviews	Stop 5G UK	5G concerns	(Stop 5G UK, n.d)
	ISP Review		(Jackson, 2020, February 7)
Welsh Government: Public Health England response	Welsh Government		(GOV.UK, 2019)
UK Government & Media reports	Security & Huawei concerns		(NCSC, 2020)
Breaking news: Wales to Benefit in Openreach's Largest Ever 'Hard to Reach' Full Fibre Build	News release	Immediate changes to Openreach full fibre strategy in Wales	(Business News Wales, 2020, July 31)

5.10.1 Digital Pembrokeshire – Website, Facebook, Twitter

The Digital Pembrokeshire website explains the vision and provides the geographic maps to detail the strategy (2019). The Twitter account reveals the results of the 2019 County Survey (Digital Pembs, 2019, September 16) and the infographic summary of the 150 respondents (Figure 5.35). The "who is following who" on Twitter (e.g. 27 following & 46 followers – primarily local authority, Welsh Government, DCMS & local citizen sector organisations such as the Pembrokeshire Local Action Network for Enterprise and Development (Planed) (Digital Pembs, 2019b). The Facebook page lacked traffic, but it is a central repository and recognised marketing tool to support door to door engagement (Digital Pembs, 2019a). Future research could include more in-depth analysis of the social media platform effectiveness.

Figure 5.35 PCC County Show 2019 Broadband Survey - infographic (Twitter & Facebook pages)



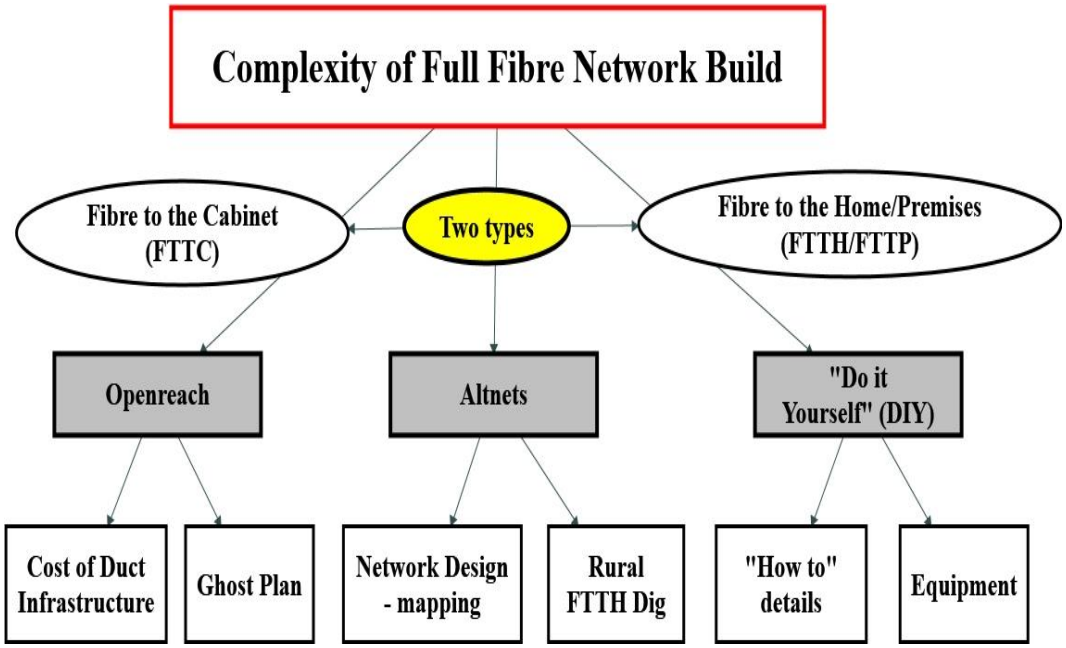
**The full Infographic can be found on both the Twitter feed & Facebook page for September 2019.*

5.10.2 Complexity of full fibre network build - Supplier challenges

A core finding of this research is the complexity of the full fibre network build. It is therefore worth noting some of the complications that commercial suppliers and "do-it-yourself" (DIY) options experience (e.g. the technicalities of the civil engineering works, the network planning & design, the cost of equipment & so forth).

The following is a brief explanation of some of these technical challenges taken from documents and instructional videos found on YouTube. Openreach has its legacy issues to contend with, but new alternative network suppliers can build an entirely new full fibre network infrastructure that is not curtailed by any legacy issues. More specifically, the desire of the PCC Pilot Projects is to get quotations on an entirely new full-fibre network. Detailed definitions for all technical terms can be found in (Appendix B). The complexities of full fibre network build are summarised in (Figure 5.36).

Figure 5.36 Complexity of network build – supplier challenges



In summary, there are two types of fibre installation for Fibre to the Cabinet (FTTC) and Fibre to the Home/Premise (FTTH/P) explained in the research context (Section 2.3.4). Further details of the technical challenges will be explained in the following sections.

5.10.2.1 Commercial - Complications of full fibre network build (UK)

The initial explanation of Openreach "motorway" example provided in (Section 2.3.4) explained the difference of having a dedicated Ethernet fibre line (Active Optical Network or AON) or shared broadband (Passive Optical Network or PON). To expand on some of these challenges' suppliers face when installing full fibre, more examples are provided. For example, The Optical Networker video (The Optical Networker, 2017, September 9) summarises the two FTTH/P architectures:

1. "Point to Point" (P2P) Active Optical Network (AON) - is Ethernet network with dedicated length to your service providers equipment & does not compete with bandwidth with other users.
2. "Point to Multi-Point" (P2MP) Passive Optical Network (PON) - which shares resources & equipment with other users. There are different types of PONS, including GPON (gigabit capable), EPON (ethernet) & BPON (legacy broadband being phased out). GPON is important for FTTH.

5.10.2.2 Previous broadband installations – Prior to full-fibre

Prior to full-fibre networks, there are two kinds of copper broadband supply: one is using copper lines and the other cable (or twisted copper pairs & coaxial cable). For example, Virgin uses Data Over Cable Service Interface Specifications (DOCSIS). Landline broadband works with splitting the copper into two channels: voice and data. This is called Digital Subscriber Line (DSL). Types of DSL used are Asymmetric Digital Subscriber Line (ADSL) which allows the download speed is faster than the upload speed (e.g. 24 Mbps down & one Mbps up). The other is Very High Bit Rate Digital Subscriber Line (VDSL) which allows for faster upload and download speeds (e.g. 100 Mbps down & 20 Mbps up). Both ADSL and VDSL have distance limitations (e.g. less than 5km & 1km respectively).

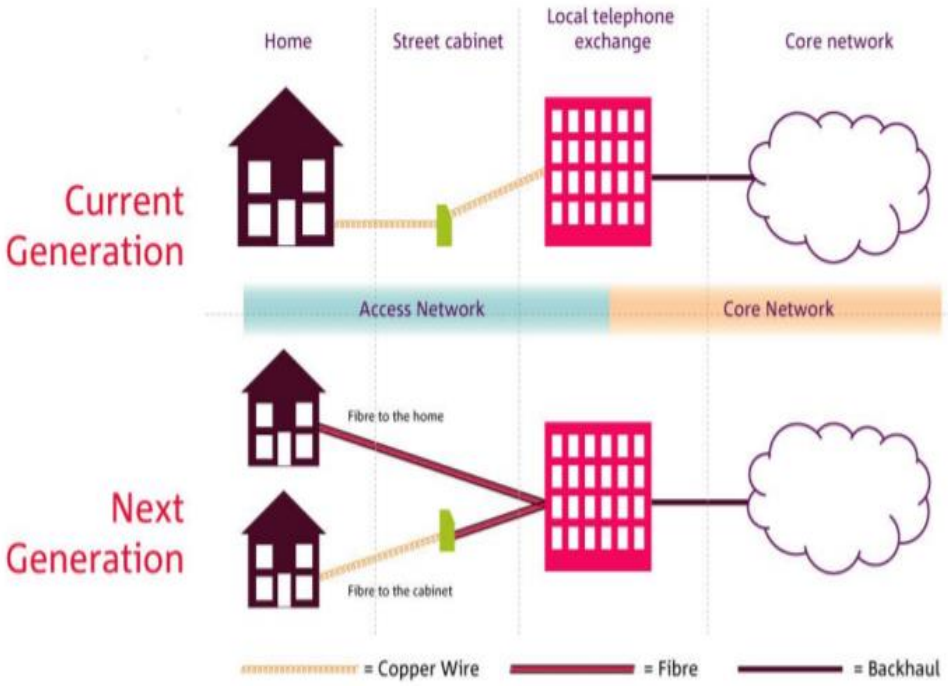
Currently, telecommunication providers supply fibre with two approaches: Fibre to the Cabinet (FTTC) and Fibre to the Home (FTTH). In the UK, they use the terminology Fibre to the Premise (FTTP), but the rest of world uses FTTH. This thesis uses these terminologies interchangeably, because FTTH resonates more personally than FTTP. FTTC reduces the length of copper by placing a fibre line to the cabinet, and then copper to the home/premises. Inside the cabinet is a Digital Subscriber Line Access Multiplexer (DSLAM) which uses VDSL (which is not fibre optic).

As previously explained in (Section 2.3.4) it is essential to understand what "fibre" means (e.g. glass transmitting light pulses), and whether the line is shared or dedicated. It is also notable to understand the difference between FTTC with copper-line to the house (Figure 5.37) versus FTTH.

In contrast to FTTC, FTTH bypasses the old copper line but has lengths of 20km and upload of one Gbps. The only downside is the cost of the civil engineering to dig the ducts and trenches to connect the property (The Optical Networker, 2018, May 5). This is essential to understand the challenges Openreach faces when "migrating" over from the copper lines to full fibre, and how Altnets can build full-fibre networks from scratch (e.g. no copper legacy or migration issues). A simplified summary of network architecture is provided in (Figure 5.37).

Figure 5.37 Network architecture - example

(Ofcom, n.d)



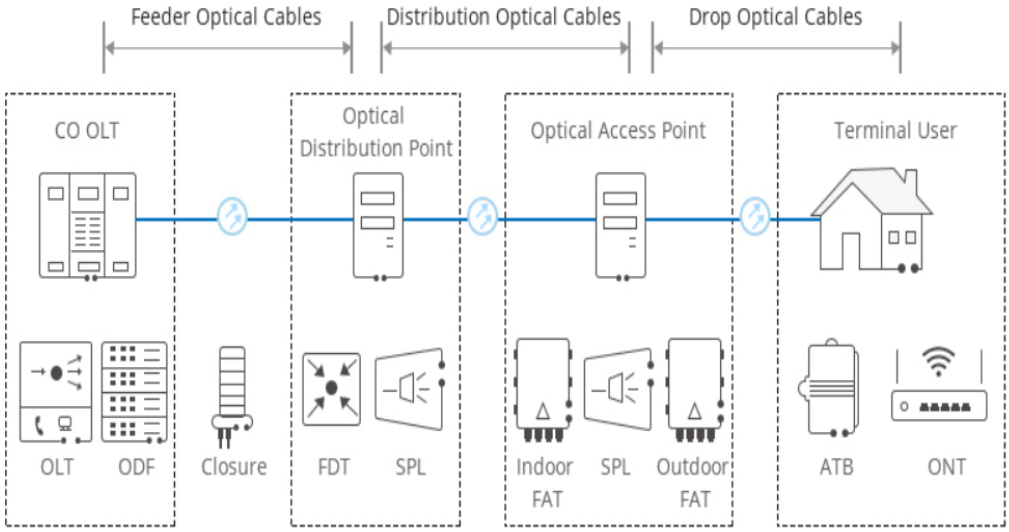
5.10.2.3 Alternative networks – Overlaid network design and build costs (USA)

Real World Systems video (2015, July 15) explain the complexity of building a network through their FiberPlanIT software package. The video details how the software can help suppliers cost their projects up front by using their overlaid network mapping software. According to Real World Systems, previous mapping efforts included manual design with CAD drawings (e.g. 1000 homes per month efficiency) or Geographic Information System (GIS) design following pre-determined routes (e.g. 3000-5000 homes per month efficiency). By improving the design planning process, their system claims to increase efficiency (e.g. 10,000-50,000 homes per month).

The preparation of areas and the selection of location, clusters, and routes to cost, design, and plan network deployment more effectively. The video shows how to use "Open Street Map" (open source) to identify the geographical area of premises to connect. The authors show how to cost a FTTH network deployment for 1200 homes. The video visually explains the challenges that Openreach, and other FTTH network suppliers have to face. The terminology is USA based, but the "overlaid network" explanation helps to understand the landscape. The 1200 property example explains how the $3 million total project cost are calculated. For example:

i. *Public trenching* (48% of build cost) – most expensive as this is the civil engineering works of digging trenches & ducts.
ii. *Home costs* (11%) - extra connections per building & customer premises equipment (CPE).
iii. *Drop costs* (16%) - aerial cables (2-4F), drop box, ducts, splice & trenching costs.
iv. *Distribution* (16%) – aerial cables (24F), cabinet, cables, closure, duct, handhold, micro duct splinter, splice, splitter costs.
v. *Feeder* (5%) – cable (12-48F), Central Office, closure, ducts, handhole, manhole, ODF (optical distribution frame), OLT PON (optical line termination), OLT shelf, splice.

Figure 5.38 Fibre Optic Passive Optical Network (PON) - example (Community FS, 2015)



All of these factors are "layers of the network". The *"feeder layer"* includes the Central Office (e.g. Headend or Parent Exchange in UK), feeder to clusters of buildings/homes, feeder cables (aerial or underground) and ducts. The *"distribution layer"* includes distribution points, distribution clusters, distribution cables and ducts. The *"drop layers"* include connections to the houses/buildings (aerial or underground). The *"equipment layer"* costs which include cables, handholes, manholes, cabinets, primary cabinets, and central office (explained below in Mr. Watkins DIY FTTH build). All of these material costs will need to be managed once

installed, and this software suggests integrating with General Electric (GE) "Physical Network Inventory" (PNI) solution for full network lifecycle management. This video helps users understand the complexity of overlaid network costs, design and ongoing management. This kind of complexity is also explained in detail with the UK Market Test Pilot Cybermoor "Broadband in a Box" (Cybermoor, 2016).

In summary, the above example provides comprehension on how a $3m build cost for 1200 (urban) properties is comparative to costs incurred for rural deployment with much longer distances for feeder, distribution, trenching and drop costs. This example provides a helpful illustration of the disparity in sharing costs amongst 20 rural properties versus 1200 urban properties.

5.10.2.4 "Do it Yourself" (DIY) - FTTP home network (UK) (RQ1)

For further detailed technical comprehension, particularly with understanding the various equipment and connections. John Watkins video shows how he constructed an entire DIY (FTTP) network in rural England (Watkins, 2016, October 16). Mr. Watkins shows in detail how he installed the base station build and mast, including all of the technical equipment inside the cabinet and handhole. The author shows the running of the cables into the barn and where his DIY cabinet and rack is stored to house all of the different technical products, including PON splitter, switches, router, and Huawei GPON OLT (Optical Line Servers) and so forth. He shows his DIY "cable trailer" that he made himself to run the cable across the land. An excellent example of Von Hippel's "user innovation" (Section 3.7.3). He shows how a farmer helped dig the trenches (human & social capital) and how the cables run down the side of the lane into another handhold where the fibre slice closure (two tubes in & out). Mr. Watkins walks through the entire technical set-up of splitters, OLT (optical line termination) and routers. In another video, Mr. Watkins shows how he runs a 1.1 km fibre overland to his barn (Watkins, 2016, December 16).

5.10.2.5 Rural FTTH dig – Complications & variety of options (Denmark)

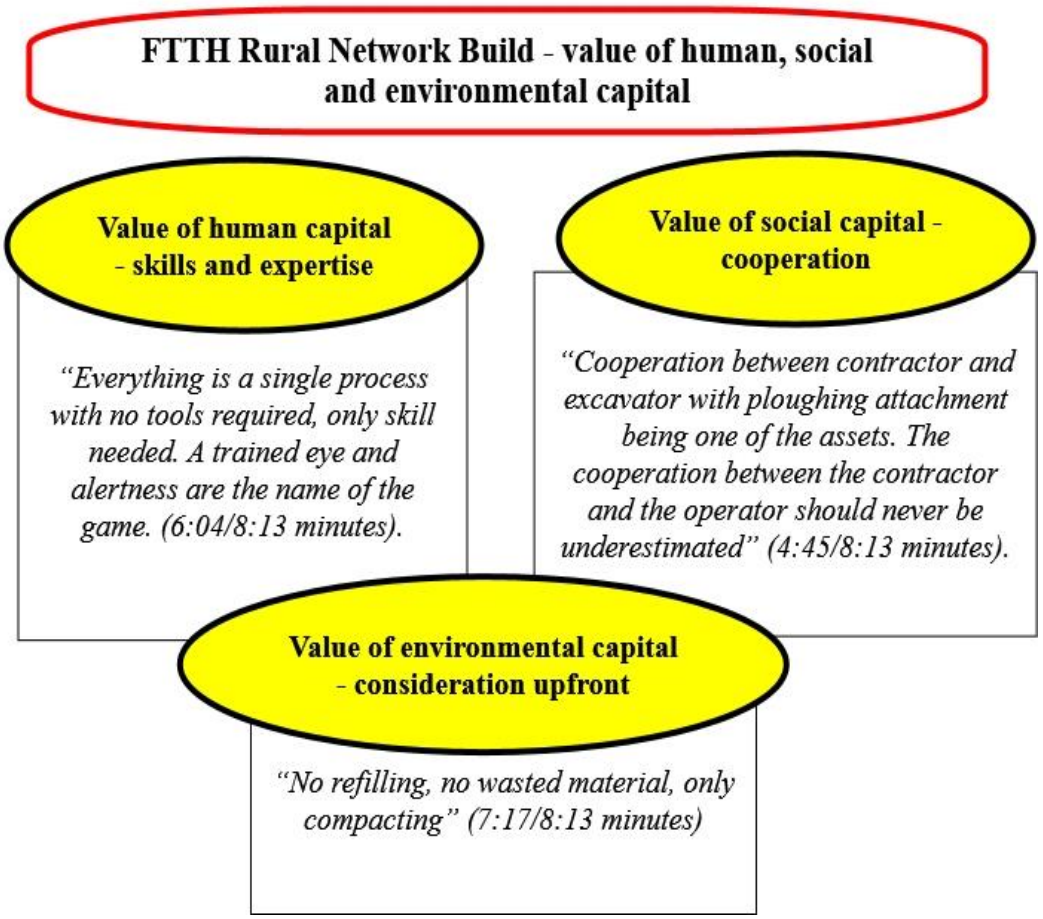
GM Plast A/S is an informative YouTube channel and has posted a large amount of explanatory videos to help interested parties and suppliers in how to deploy fibre through various dig sites, including blowing cable techniques, colour cabling, micro-trenching, specially adapted dig equipment and so forth (GM Plast A/S, 2013, October 3, 2015, September 8). The cost of deploying FTTH in rural areas is largely down to

the cost of the civil engineering works because of the distances to dig the trenching for the fibre (GM Plast A/S, 2015, September 8).

5.10.2.6 The value of HC, SC & EC – FTTH rural network build (RQ1&2)

A significant finding in the video, is another example of the value of "user innovation" (GM Plast A/S, 2015, March 24) and how the excavator designed a ploughing attachment which greatly improved the technique for micro-trenching. The video highlights the value of human capital (e.g. skills), social capital (e.g. cooperation), environmental capital (e.g. minimum environmental disruption) and financial capital (e.g. efficiency savings) which is summarised in (Figure 5.39).

Figure 5.39 FTTH rural network build - value of HC, SC & EC - quotation map



5.10.2.7 Openreach – "The Ghost Plan" (UK)

A partial explanation of the rural Openreach anomaly was briefly explained in (Section 5.8.6). A more detailed explanation on how the Parent and Child Exchanges to be phased out is based on Openreach UK strategic plan called "the Ghost Plan" (Openreach, 2018).

Openreach (INT3) explained that a consensus is building that the UK needs a nationwide all-fibre network to serve the needs of citizens and businesses in the future. Fibre to the Premises (FTTP) is seen as the only truly future-proof access technology. It is ultrafast, upgradeable, reliable, cheap to operate and has predictable performance. Openreach has the ambition to build that network. They have the skills, scale, and proven track record to deliver, however competitors are becoming increasingly active. A national UK fibre network would be the second biggest infrastructure project the UK has ever seen (second only to HS2) (CeBR, 2019). It is the equivalent to rebuilding the entire copper network, but it is expected to be built in years, not decades. This is requiring a new way of working for Openreach (2019a).

For accuracy, the following quotation was taken from (INT3, Openreach) correspondence. A visual diagram is presented in (Figure 5.40) taken from PowerPoint Openreach "Fibre First" Ambition supplied by (INT3).

Openreach Ghost Plan – complexities of network build

What is the Ghost Plan?

The ghost plan is a network blueprint of how Openreach should deploy fibre throughout the UK. It shows where the ***Aggregation Nodes****, **Universal Nodes**** *and* ***Connectorised Blocks**** *should be placed and what size fibre cables should be deployed between them. Openreach has a ghost plan for every exchange in the country of how they would build a full Single Fibre Network (SRN), ready for when they go and build there.*

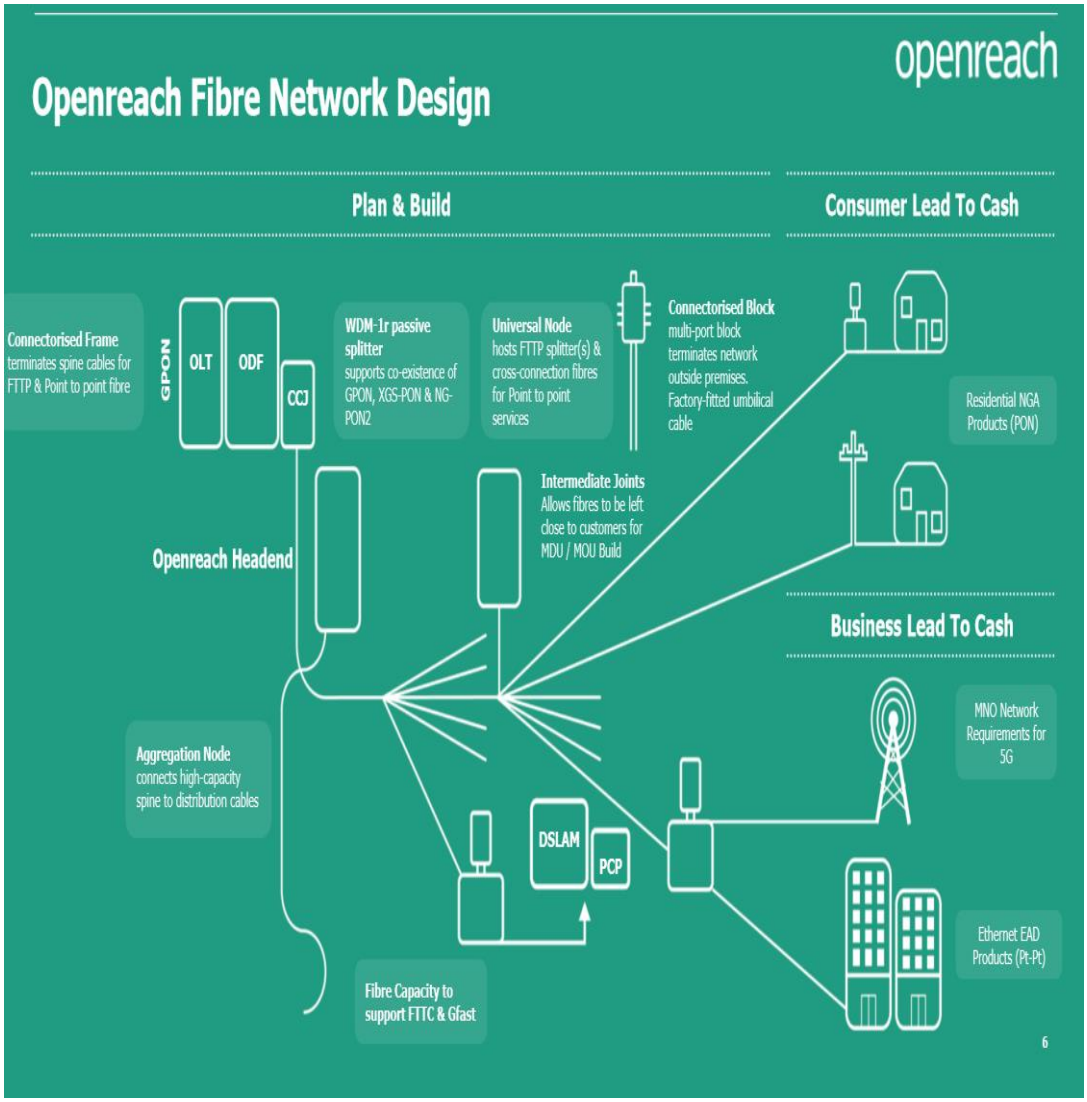
Key Principles in the Ghost Plan

a) *Single Fibre Network (SFN): is based on Openreach SFN architecture and connectorised components to build capacity for both FTTP and Ethernet.*
b) *Build Once Policy: The ghost plan provides FTTP to at least 106% of premises and enough fibre to serve the demand for Ethernet "point-to-point" fibre connections for at least 5 years. This recognises that it is much cheaper to build enough capacity once than to keep going back again and again to add small amounts of incremental capacity*
c) *Best Customer Experience: Connectorised blocks are placed close to customer premises to support a 1-hour single engineer installation (overhead) or 2 hours (underground).*
d) *Compliant to Policies: The ghost plan reflects the latest fibre build & planning policies.*

Definitions (Figure 5.39)

**Aggregation node – connects high-capacity spine to distribution cables*
**Universal node – hosts FTTP splitter(s) and cross connection fibre for Point to Point (POP) services*
**Connectorised Block – multi-port block terminates network outside premises*
**Connectorised Frame – terminates spine cables for FTTP and POP fibre*

Figure 5.40 Openreach "Fibre First" Ambition
(12 October 2018, PowerPoint, p. 6)



5.10.2.8 Underground duct construction - Cabling surveys 1960 (BT Archives)

Another example of how complicated the underground cable network (urban) and ducting is; a BT Archive Film from 1960s shows how a planning team walks a route from the telephone exchange and how the survey helps to ensure the best possible planning and routing of the underground ducts to the streets and premises above. This film is a good example to explain the complexity and cost of civil engineering works and how the underground cables are planned and managed overtime (BT Film Archive, 1960).

5.10.2.9 How a full fibre network is built - Openreach Fibre Broadband

Finally, Openreach provides an overall summary on how the company intends to build the fibre broadband, and the stages of connectivity of FTTC, FTTH/P and wireless, satellite and TV Whitespace for the hard-to-reach areas (Openreach, 2012, June 21).

5.10.2.10 Summary of complexities of full fibre network build

In sum, the YouTube instructional videos provides a helpful visual understanding of what Openreach, Altnets and DIY decision-making and challenges suppliers face when building full fibre networks. A summary table of the complexity document analysis can be found in (Appendix K, Table K.4).

5.10.3 "Stop 5G" – Health & surveillance concerns

The focus thus far has been primarily on full fibre and less on 5G. The reason for this is because 5G is not without its detractors. Some opposition has arisen to stop the 5G roll-out. Mr. G advised there were some environmentalists travelling around the countryside trying to raise awareness that 5G connectivity is detrimental to our health.

The UK and Welsh Governments have posted public health advice (GOV.UK, 2019) to alleviate some of the health and safety concerns about 5G, but some groups are determined to halt the implementation of the technology (Stop 5G UK, n.d). A helpful article to explain and mitigate the health concerns over 5G was in the ISP Review (Jackson, 2020, February 7). In this researcher's opinion, it is a balanced review of the various radiation waves people are already subject to (e.g. microwave ovens, the sun & so forth). Moreover, UK5G posted a Spectator article to fight back against some of the "conspiracy theories" (Jackman, 2019), but until the UK Government can actively show that beam forming and the close proximity of the mobile masts required for 5G (e.g. 30 metre distances apart to enhance latency for autonomous vehicles) the health concerns are unlikely to go away. Whether or not this stops the roll-out of 5G across the UK is yet to be seen.

In addition to health concerns, are the "surveillance concerns", or as Mr. G and INT13 (Altnet) explained some people are calling it the "Internet of Threats". Surveillance concerns over the Chinese company Huawei and the potential threat to business and national security, resulted in the UK Government voting to stop their involvement (Smith, 2020, March 10). More specifically, cybersecurity, data

protection, privacy and so forth are critical support functions as "full fibre & 5G" rolls out. Henceforth, the National Centre for Cybersecurity (NCSC) and the UK Government are actively working to address these concerns amidst supply chains (NCSC, 2020).

In brief, full fibre is needed regardless of whether or not 5G is a welcome technology or not. If the nation wants to invest in autonomous vehicles, then a 5G-type architecture will be needed to allow for zero latency (e.g. time lag). Hence, 5G is not the primary focus of this thesis, but addressed as one part of the governments NGA ambitions for Industry 4.0.

5.10.4 Wales to benefit in largest ever "hard to reach" full fibre build

Breaking news on July 31, 2020. Openreach announces that Wales is to benefit from the largest ever "hard to reach" full fibre build without taxpayer subsidy (Business News Wales, 2020, July 31). The article cites findings from the CeBR report (identified above Table 5.4) and the potential economic, environmental and social benefits for Wales (CeBR, 2019). For example, full fibre connectivity could boost the Welsh economy by £2bn, return 25,000 people back into the workforce, allowing next-generation home-grown businesses and working from home (Business News Wales, 2020, July 31). The potential de-urbanisation could save 300 million commuting trips or 360,000 tonnes of carbon emissions (CeBR, 2019, p. 9). Another recent Openreach article found doctors treating patients remotely via video-link with telehealth appointments, can reduce carbon emissions by 40-70 times (Openreach, 2020, January 20). These environmental and social benefit assertions are compounded by the COVID19 outbreak and the need for improved connectivity. This additional investment announcement by Openreach is another opportunity to reach the final few in Wales and improve the economic outcome post-COVID19.

5.10.5 Summary of document analysis (Tier Three) (RQ1, 2 &3)

Additional documentation analysis (Tier Three) was required as a result of findings from exogenous supply and endogenous demand interviews. The conclusions drawn are that the PCC Digital Pembrokeshire "first of its kind" initiatives have taken a holistic and proactive digital brand approach to engage the county and rural communities (RQ3). The litmus test for this initiative will be whether or not the PCC was able to put "glass in the ground" and achieve its "full fibre & 5G" ambitions or

not. Some way in the future, the overall results on whether, or not, PCC was successful would be an area of interest for future research.

The Openreach "anomaly" highlighted the complexity of the challenge's suppliers face in rolling out NGA products and services to the final few. Understanding the complexities of the network build is critical to resolving the digital divide (RQ1 &2). New funding opportunities identified by the Altnets and the constantly changing funding streams from UK Government, Welsh Government, Welsh Assembly, and local authorities can aid this process, but the fundamental comprehension on what it takes to roll-out full fibre is required (RQ1 &2). Finally, 5G continues to be a controversial topic for health & safety, surveillance concerns and recent political discourse involving Huawei. Regardless of the 5G controversies, full fibre connectivity is now an essential requirement post-COVID19. There are five themes identified in the document analysis and summarised in (Table 5.7).

Table 5.7 Summary of five themes in document analysis (Tier Three)

Number	Theme	Potential Intervention area	RQs
Theme 1	PCC survey results – validating rural demand.	Triangulated findings.	3
Theme 2	Complexity of network build & costs.	Multiple – collaboration, knowledge share & strategic partnership opportunities.	1 & 2
Theme 3	Value of HC, SC, EC & SFC to resolve complexities of network build.	Multiple – collaboration, knowledge share & strategic partnership opportunities.	1 & 2
Theme 4	Stop 5G.	Multiple – how to mitigate health, privacy & surveillance concerns.	2
Theme 5	Wales to benefit from largest ever hard to reach – environmental, economic & social benefits.	Multiple – collaboration, knowledge share & strategic partnership opportunities.	1, 2 & 3

**LDC (local digital champion), HC (human capital), SC (social capital), EC (environmental capital), SFC (shared financial capital).*

5.11 Conclusion - Nation-level (macro) findings (RQ1, 2 & 3)

In summary, the nation-level contextual issues facing the Splits-Ville case study area are numerous and across governmental, commercial supplier and DIY options. A summarised table of the five cross-cutting themes identified in the observations, interviews and document analysis are provided in (Table 5.8).

Table 5.8 Overall summary of five cross-cutting themes - nation-level

Theme	Exogenous Supply	Endogenous Demand	Document Analysis	RQs
1	First in Wales – local authority & rural community-level – centralised hubs & roles to reach final 95k. (RQ3)	Rural DIY – enforced LDC HC & SC to reach Splits-Ville (RQ1 & 2).	PCC Demand Survey – triangulated rural broadband findings. (RQ3)	1-3
2	Value of HC for productivity - to reach the final 95k. (RQ1)	Value of HC for productivity - LDC & rural MB experiences – triangulated results. (RQ1 & 2)	Value of HC & SC – throughout network build. (RQ 1& 2)	1-3
3	Value of SC for collective action - to reach the final 95k. (RQ1)	Value of SC for collective action – RSCAT informal SC & Community Spirit (RQ 1& 2)	Stop 5G – health, privacy & surveillance concerns. (RQ2)	1 & 2
4	Value of SFC opportunities - to reach the final 95k. (RQ1)	Central Hub failure for SFC – local authority & rural community level to allocate funds. (RQ1 & 2)	Wales to benefit from largest ever hard to reach investment – HC, SC, EC & SFC benefits. (RQ1-3)	1-3
5	Complexity of network build – stranded assets & timebound contracts.	Complexity of network build & legacy issues – Openreach anomaly.	Complexities & costs of full fibre network build.	1 & 2

** EC (environmental capital), HC (human capital), LDC (local digital champion), RSCAT (Rural Social Capital Assessment Tool), SC (social capital), SFC (shared financial capital).*

The first cross-cutting theme key words in the supply ecosystem are the proactive, "First in Wales", local authority-level, rural community-level, centralised hubs, centralised repository, barrier busting, conflict resolution and communication (Section 5.2.5). The "First in Wales" proactive initiatives have identified the *local authority* as a key stakeholder in resolving the digital divide. The introduction of the EOs in particular is notable. The success or failure of this initiative will determine if the local authority is a bridge to reaching the final 95k or will rural communities have to resort

to previous DIY options. Key words in the demand ecosystem are the DIY options and the enforced engagement of the LDC to enable SFBB in SV-A (Section 5.8.1). The PCC survey analysis confirms the demand for NGA services in Pembrokeshire (Section 5.10.1).

The second cross-cutting theme in the supply ecosystem is the value of human capital for productivity to reach the final 95k. Key words and new findings are the personal attributes (e.g. proactive leadership & altruistic volunteers), knowledge (e.g. local tacit knowledge on spectrum of human behaviour) and skills (e.g. people & soft skills) required to reach the final few (Section 5.2.5, 5.4.5, 5.6.4). Key words in the demand ecosystem are similar, but with the addition of rural MBs experiences and triangulated results from other studies (Section 5.8.6). The value of human capital was evidenced in the complexities of the network build and requires recognition within both supply and demand ecosystems (Section 5.10.2).

The third cross-cutting theme in the supply ecosystem is the value of social capital for collective action to reach the final 95k. Key words include trust, relationships, networks, centralised hubs and roles including mediators, knowledge brokers and strategic partnerships to resolve the digital divide (Section 5.2.5, 5.4.5, 5.6.4). These key words are similar in the demand ecosystem with the addition of informal networks and the value of Community Spirit (Section 5.8.6). The Stop 5G concerns are being highlighted across the countryside, but time will reflect the impact (Section 5.10.3). Regardless of 5G, full fibre reliability is recognised as an essential requirement post-COVID19 (Section 5.8.8).

The fourth cross-cutting theme in the supply ecosystem are the new SFC opportunities and the potential to allocate funds at the *local authority-level* (Section 5.2.5, 5.4.5, 5.6.8). Key words in supply ecosystem are £80 million clawback funding, DIIF, DPS, new £10m community fund, £2m PCC gap fund, SBCD digital infrastructure funding, vouchers and the Wall of Money for private investment. Lack of human capital skills for investment have been identified (Section 5.6.6). In the demand ecosystem key words are the failure at local authority-level and Openreach CFP to act as centralised hubs to facilitate funding and support for Splits-Ville (Section 5.8.2.3). However, Openreach is now taking proactive measures to reach the final few

with non-taxpayer subsidies (Section 5.10.4) which can enable human, social, environmental and financial capital benefits in Wales.

The fifth cross-cutting theme across supply and demand ecosystems is the complexity of the network build which requires human, social, environmental and shared financial capital comprehension and knowledge share to address the challenges of reaching the final 95k. Key words include costs for rural, labour shortages, legacy issues, new commercial supplier HC & SC roles, Open reach anomaly, stranded assets and timebound contracts (Sections 5.4.5, 5.5, 5.6, 5.8.2 & 5.10.2)

In conclusion, the unequivocal value of HC & SC exhibited in the "First in Wales" local authority-level initiatives is tantamount to the success of reaching the final 95k (RQ1). Nevertheless, there are intricate nuances within human capital productivity & social capital collective action that require further investigation (Chapter Six). In addition, there are mutual learning and cooperative interplay opportunities within complex ecosystems (RQ2), and new and innovative approaches to explore (RQ3). The potential intervention areas are numerous and will be considered further in the local-level analysis (Chapter Six).

Chapter Six: Productivity & Collective Action

6.1 Introduction & Chapter Overview

Nation-level (macro) contextual findings of both complex ecosystems involving the final few case study are summarised in (Section 5.11). This chapter analyses data using the five cross-cutting themes identified in (Section 5.11, Table 5.8). These include value of human capital (HC), social capital (SC), shared financial capital (SFC) at local-authority level and how the complex ecosystem-networks might interact to reach the final 95k.

Critical success factors (CSFs) for human capital productivity & social capital collective action identified in both ecosystems, will be addressed in this chapter. For example, what CSFs are required within the exogenous supply ecosystem for HC to be productive in resolving the digital divide? What CSFs are required for SC and collective action to reach the final 95k? Conversely, what barriers or hindrances are identified that obstruct HC productivity in this context? What barriers or hindrances are identified that obstruct SC collective action in this context? A fundamental distinction in this analysis is that the exogenous supply ecosystem is *network-based*, while the endogenous demand ecosystem analysis is *place-based* in relevance to the context of the case study.

This chapter addresses the research questions (RQs), and the format will follow the analysis of the four-fold capitals to answer (RQ1) (Section 6.2). The CSFs for HC productivity in the exogenous supply ecosystems and the hindrances therein are discussed (Section 6.3). The CSFs for SC collective action in the exogenous supply ecosystem and the hindrances therein are presented (Section 6.4). The CSFs for HC productivity in the endogenous demand ecosystem will be analysed (Section 6.5). The CSFs for SC collective action in the endogenous demand ecosystem will be discussed (Section 6.6). A summary of capital contributions is presented (Section 6.7). The mutual learning and cooperative interplay within the complex ecosystems to answer (RQ2) will be examined (Section 6.8). Summary results of HVS are shown (Section 6.9). New innovative approaches to answer (RQ3) began in (Section 5.4) but will be summarised in the discussion (Chapter Seven). Credibility, reflectivity, reliability and

validity will be addressed (Section 6.10). Conclusion of the thematic network analysis is summarised (Section 6.11).

6.1.1 Data reduction – Operational definitions, coding & display

As explained in (Section 5.1.2) intimate inspection of the operational definitions is crucial for the shaping of this analysis. Definitions are taken from the Cambridge Dictionary online and where applicable business definitions are used (Appendix K). The subtleties of particular definitions will highlight key words in *italics* within each section and then re-introduce them in the summary. Hence, each section will identify the significant operational definitions relevant to answering the RQs, but the overall coding process and summaries can be found in (Appendix J.3 & K).

6.2 The four-fold capital resources (RQ1)

The four-fold human (HC), social (SC), environmental (EC), and shared financial capital (SFC) are a primary focus of this thesis. RQ1 is what capital resources, both financial and non-financial, are required to support infrastructure to enable NGA to be viable for rural communities and MBs? The answer to this question has been sought throughout (Chapter Five) and the various SFC opportunities now available in Wales (Section 5.11). Further analysis of the mutual learning and cooperative interplay opportunities of SFC will be discussed below in (Section 6.8.2).

EC was not a primary focus of this thesis, but due to the COVID19 outbreak, the use of ZOOM video conferencing, working from home and the changing face of work phenomena has taken a dramatic turn (Section 5.8.8). Regardless of whether or not 5G will be implemented, the need to affirm health and surveillance concerns is still to be determined (Section 5.10.3). Nevertheless, full fibre is required to support any technology used in the future. The purpose of this thesis, alongside SFC and EC, is the value of HC & SC as the theoretical underpinning and non-financial value-add which are analysed in the following sections (Section 6.3 - 6.6).

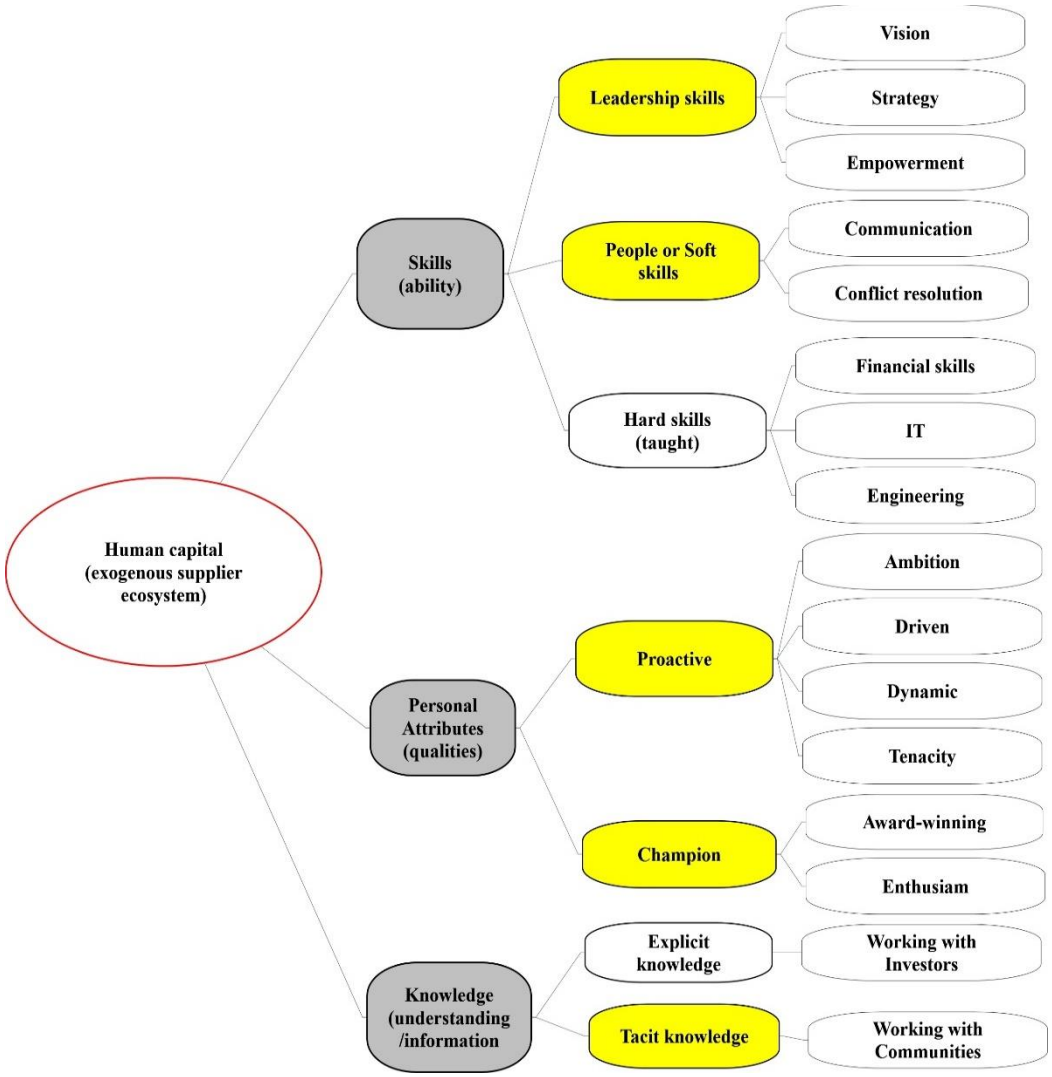
6.3 Exogenous supply ecosystem (HC) – Network-based (RQ1)

Both the exogenous supply and endogenous demand ecosystem identified the value of skills (e.g. *abilities*), knowledge (e.g. *understanding* of; *information* about), and positive personal attributes (e.g. individuals' *qualities*) that contribute to human capital productivity to get the job done and reach the final few. What follows is the exogenous supply network-based HC analysis.

6.3.1 The value of supply human capital - Productivity

A summary of the human capital (HC) findings for the supply ecosystem is displayed in the following (Figure 6.1). The highlighted items are considered CSFs, identified in Welsh Government interviews (Section 5.4) for HC productivity within the supplier ecosystem. Each CSF will be discussed in following (Section 6.3.2 – 6.3.7).

Figure 6.1 Supply ecosystem – human capital productivity - coding results



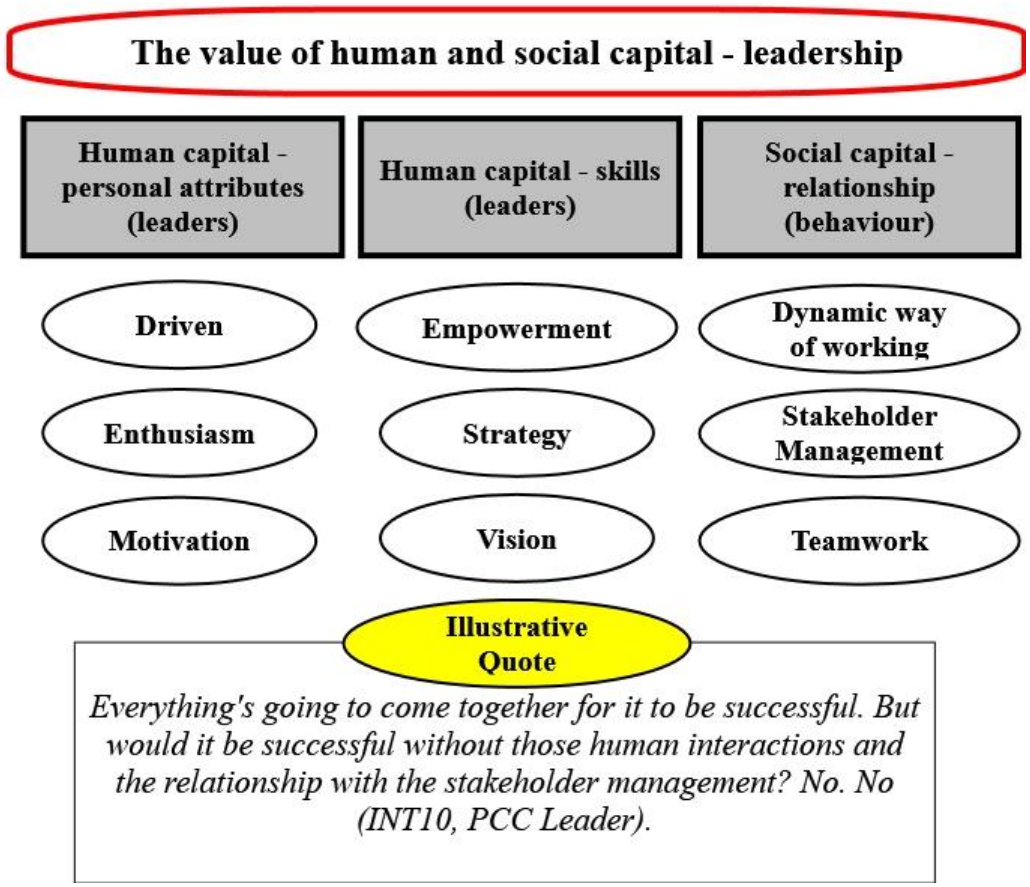
6.3.2 Leadership – Critical success factor (CSF)

A CSF identified in (Section 5.4.1 & 5.4.2) driving the "First in Wales" initiatives is the leadership, strategy and vision of the Taskforce and PCC local authority team. Leadership is defined as the set of *characteristics* that makes a *good* leader or leadership qualities/skills. Driven is defined as an effort directed towards *achieving* a particular result. Dynamic is defined as having a lot of ideas, energy, and *enthusiasm*. Enthusiasm is defined as a feeling of *energetic interest* in a particular subject or *activity* and an eagerness to be involved in it.

Empowerment is the process of *giving* a group of people more *freedom* or rights and was identified as a CSF for the Superfast Cymru project (Section 5.4.1). Motivation is defined as the *enthusiasm for doing something*: the need or reason for doing something. Strategy is defined as the way in which an entity carefully plans its *actions* over a period of time to improve its position and *achieve* what it wants; a way of *doing* something or dealing with something. Vision is defined as an idea or mental image of something; the *ability* to imagine how a country, industry and so forth could develop in the future and to plan for this.

As discussed in (Section 5.4.1) the evidence of teamwork is tantamount to the success of creating these initiatives. The definition of teamwork is the *activity of working together* as a team, or the *skills* required to do this. Stakeholder management is defined as maintaining constructive relationships towards a *shared goal*. Stakeholder management and teamwork will be discussed further in SC collective action findings. Hence, the value of leadership for human capital (productivity) and social capital (collective action) is combined in (Figure 6.2).

Figure 6.2 Leadership – supply productivity & collective action – coding results



In summary, the value of leadership as both HC (e.g. skills & personal attributes) and SC (e.g. relationship behaviour) are considered CSFs for productivity and collective action to reach the final 95k.

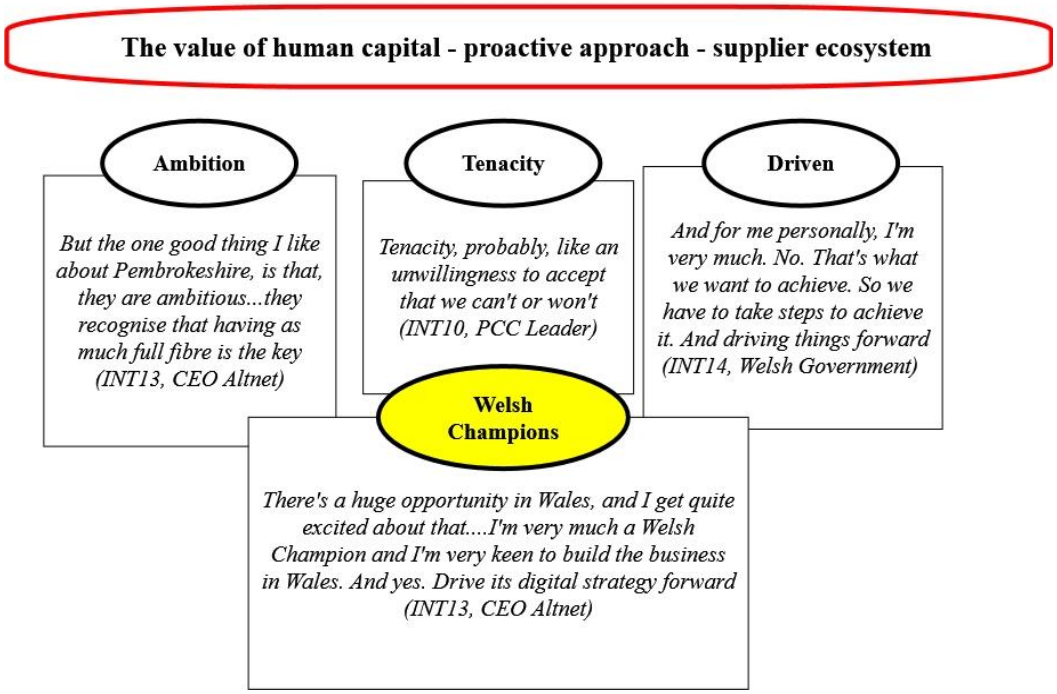
6.3.3 Proactive approach – CSF (new)

The proactive approach is a CSF and was identified as a global theme in the First in Wales initiatives (Section 5.2.2, 5.2.3, 5.4.1 & 5.4.2). The value of HC productivity and a proactive approach within the supplier ecosystem is summarised in (Figure 6.3). Proactive is defined as *taking action* to make changes yourself rather than reacting to things that happen. Please note, personal attributes of leaders and team members are interwoven within leadership findings and the proactive findings (Section 5.4.1 & 5.4.2). Both are symbiotic to each other. The dynamism and enthusiasm of the leadership team empowered the team members which inspired the teamwork. Ambition is defined as a strong wish to *achieve* a particular thing. Team players defined themselves with key words such as *driven* (defined above) and *tenacity* which is the *determination* to continue what you are *doing*.

6.3.4 Champions – CSF

In addition, a *champion* is defined as someone who supports, defends, or fights for a person, belief, right, or principle *enthusiastically*. Local digital champions (LDCs) exist within the demand ecosystem, but also within the supplier ecosystem and are proactive determinants for HC productivity & SC collective action. Product Champions were defined as CSFs within innovation management (Section 3.7.1). The award-winning result of the Welsh Government team member for successfully completing Superfast Cymru goals is notable (Section 5.4.1). Hence, the value of "champion" identification is a critical non-financial value-add for both supply and demand ecosystems.

Figure 6.3 Proactive approach – supply HC productivity - quotation map



In summary, proactive action is a non-financial resource. In addition to the exogenous supply proactive behaviour, it is vital to draw a correlation between the previously mentioned North Wales, Gwynedd "demand-side" case identified in (Section 4.7.1). The high SFBB take-up rates in Gwynedd are a result of the *proactive* behaviour of the Gwynedd local authority. As an outcome of this proactive action, the Welsh Government built its SFBB business exploitations programme upon this initiative. Another example of proactive HC, mutual learning and cooperative interplay (RQ1 & 2).

6.3.5 People & soft skills – CSF (new)

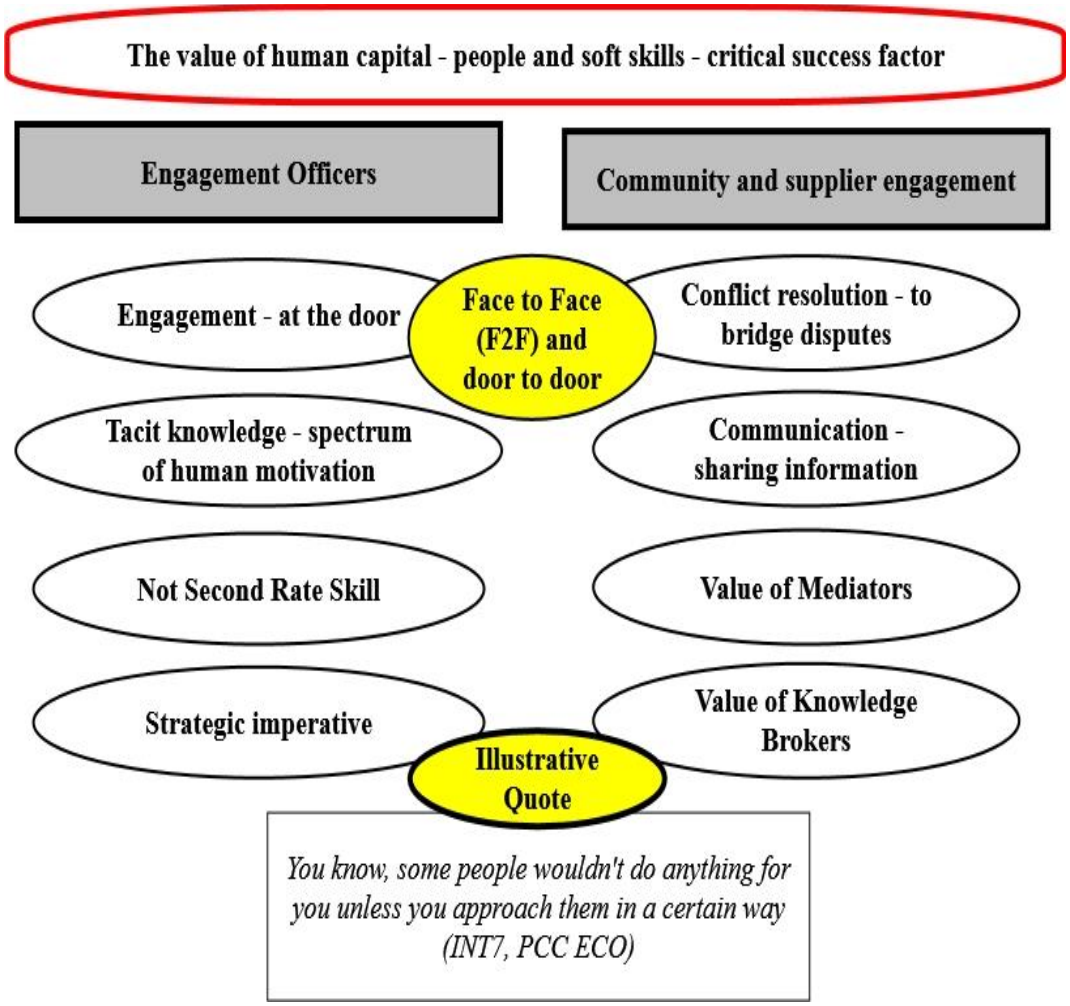
The CSF exhibited throughout the supplier interviews (Section 5.4.3) is the value of "people" and soft skills to get the job done. The definition of people skills is the ability to deal with people in a *friendly* and *effective* way that *achieves good results*. The definition of soft skills is people's abilities to *communicate* with each other and *work well together*. Conflict resolution is not as readily defined, but the following definition will suffice for this analysis (e.g. *numerous skills* coupled together to *help bridge disputes and find an agreement)*. Finally, a core skill for all activities is communication which is the process of *sharing information*, especially when this *increase understanding* between people or groups.

Please note, networks (SC) are defined as working together & sharing information, hence communication is vital for HC productivity & SC collective action within networks. Knowledge is defined as understanding of, or information about, thus *sharing information to increase knowledge* is a core assessment of this research. These interwoven concepts will be discussed further in SC network analysis below (Section 6.4).

6.3.6 Local tacit knowledge – CSF (new)

Tacit knowledge is defined as knowledge that you do not obtain from being taught, or from books and so forth, but acquire from *personal experience*. For example, hands-on experience or when working in a particular organization. Engagement is defined as an arrangement to *do something* or *be somewhere*. The value of the EOs hired to engage with the community door to door and face to face (F2F) where possible is a "First in Wales" initiative (Section 5.4.3). Equally, the value of LDCs to engage door to door and F2F with the community is a key to successful partnership for Openreach CFP (Section 5.6.1). The value of mediators & knowledge brokers as F2F relationships are required to resolve disputes between commercial suppliers and local authorities (below Section 6.4.4). All of these instances within the supplier ecosystem require people & soft skills to maintain HC productivity & SC collective action. A summary of the value of HC skills within the supplier ecosystem (Section 5.4.6) are presented in the following (Figure 6.4).

Figure 6.4 People skills & tacit knowledge – supply HC & SC – coding results



In summary, the value of people, soft skills and tacit knowledge cannot be underestimated as a non-financial imperative when dealing with local communities to get things done. However, there are positive and negative aspects to the engagement as stated in (Section 5.4.3).

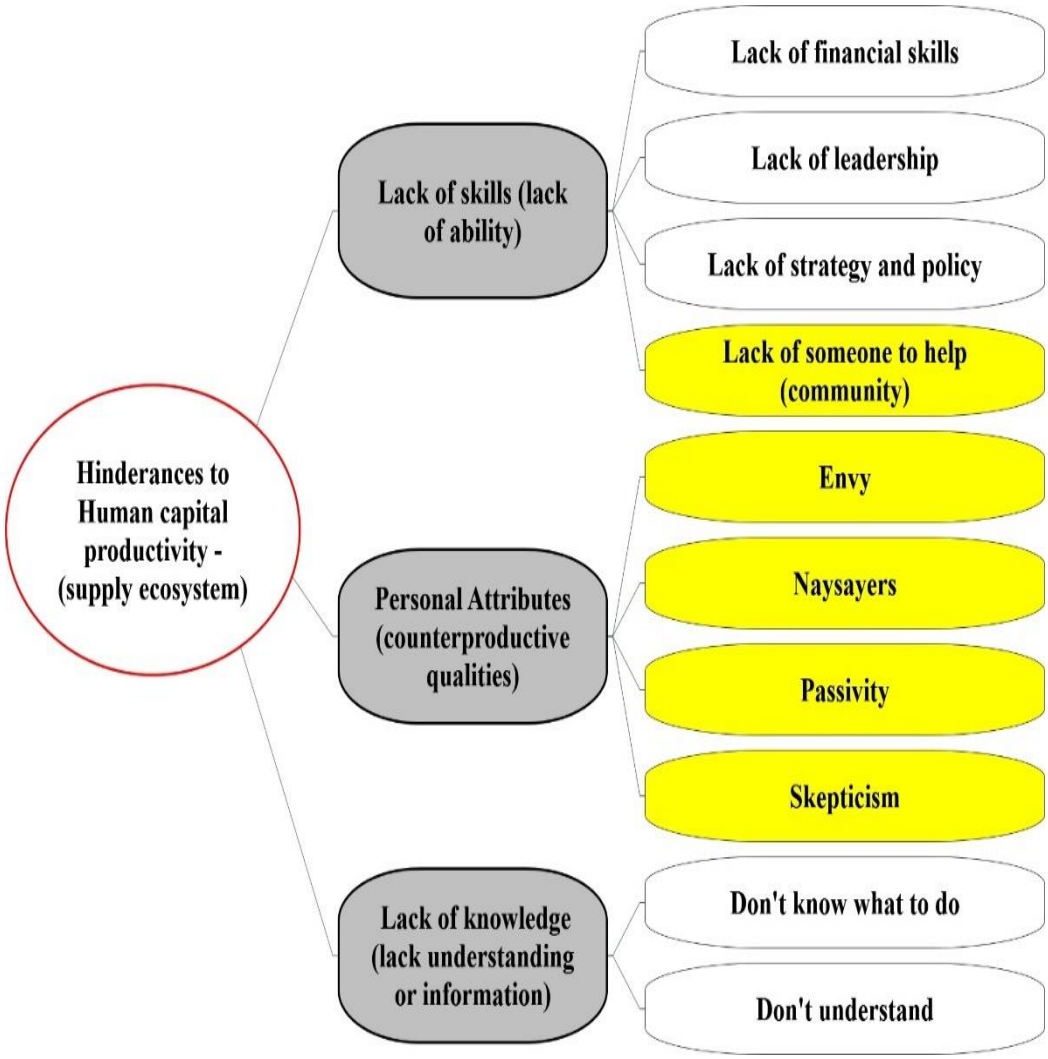
6.3.7 Hindrances to supply HC productivity (network-based)

Several hindrances to HC productivity were identified by the supplier participants. For HC to be successful these hindrances and obstacles to productivity need to be understood and where possible, addressed or mitigated.

Lack of HC was identified with the lack of financial investment skills required by the Welsh Government to organise a new market fund (Section 5.2.1) and the labour shortage to build the network (Section 5.5.2). One core finding was a suggestion made by INT12 (Welsh Government) during the October 2019 Taskforce meeting. The

suggestion was for rural communities who have aggregated demand and organised themselves to self-dig but lack the skills and time to negotiate with suppliers (e.g. would the Welsh Government consider providing funding for this "Project Manager" type-role on behalf of the community?). This suggestion will be explored further in potential intervention areas (Chapter Seven).

Figure 6.5 Hindrances to supply human capital productivity - coding results

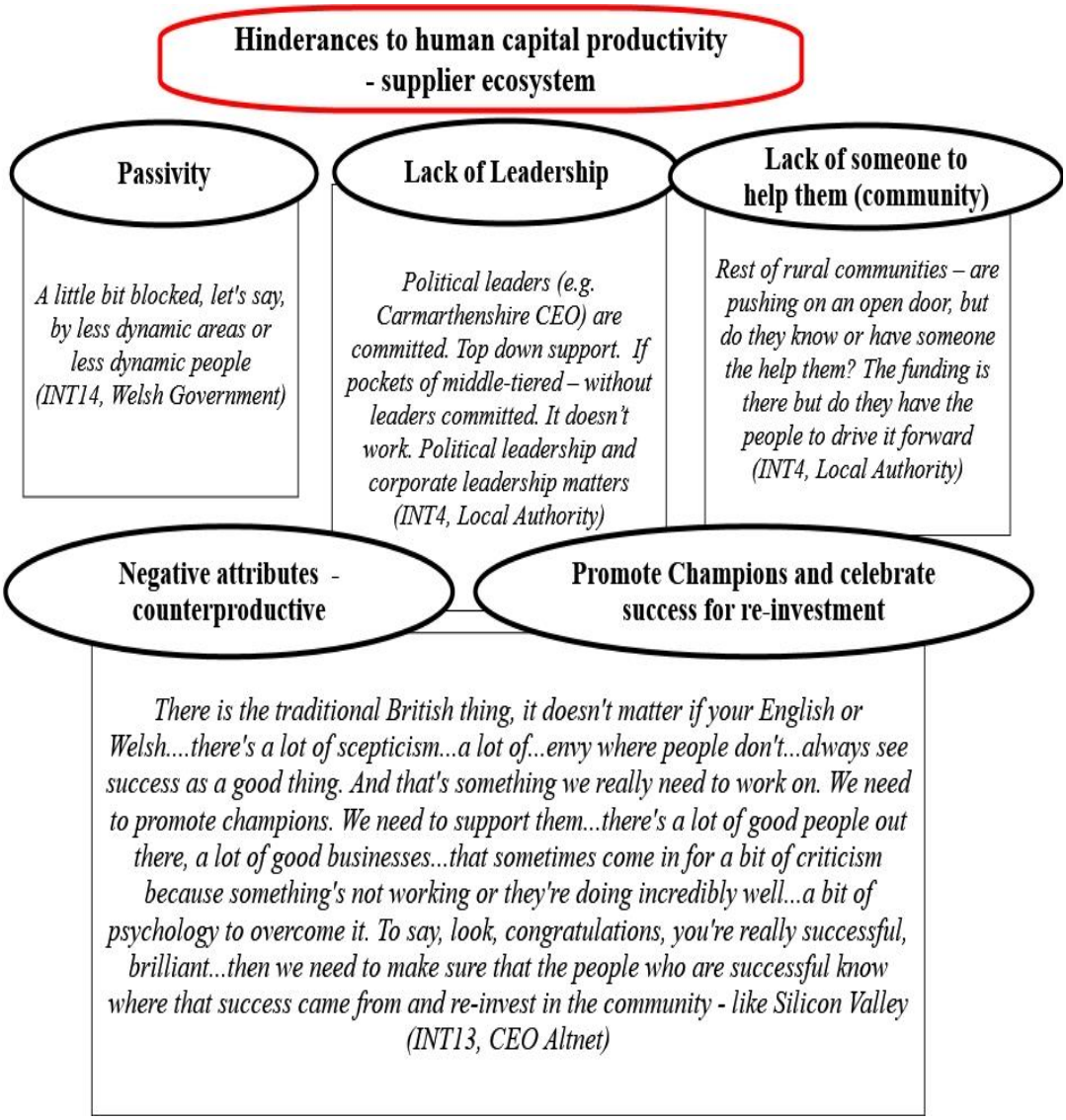


In summary, the hindrances to HC productivity within the exogenous supplier network will need to be identified and mitigated to reach the final 95k. The lack of HC skills and knowledge can be easily identified and addressed if the commercial or political will are evident. However, counterproductive personal attributes are more difficult to address, but not impossible if the right proactive leadership and teams are in place.

Hindrances to supply social capital – quotation map

The following quotation map identifies the challenges supplier participants identified as obstructions to HC productivity. A number of counterproductive personal attributes have been identified. Passivity is *not acting* to influence or change a situation, allowing other people to be in control. Envy is defined as wishing you had something that another person has. Naysayer is defined as someone who says something is not possible, is not good, or will fail. Scepticism is defined as a doubt that something is true or useful. The lack of leadership and the need for someone to help the community is identified as a hinderance to HC productivity to resolve the final 95k. A summary of these findings is presented in (Figure 6.6).

Figure 6.6 Hindrances to supply HC productivity - quotation map



In brief, hindrances to HC productivity can be overcome with determination to celebrate success and promote Welsh champions. The example given by INT13 (Altnet) is Silicon Valley, meaning success begets success, if there is positive reinforcement for people to do so. Potential supply HC productivity interventions will be discussed (Chapter Seven).

To conclude, key words for supply HC productivity include ability, achieving, activity, doing something, enthusiasm and freedom (leadership). Achieve, acting, doing (proactive). Award winning, defend, enthusiastically, fight and support (Champions). Achieve expected results, communicate and work well together, bridge disputes and find agreement, friendly and effective, increase understanding and sharing information (people & soft skills). Doing something, being somewhere, door to door, F2F, personal experience (tacit knowledge). Hindrances to supply HC productivity are not acting, doubt, not possible.

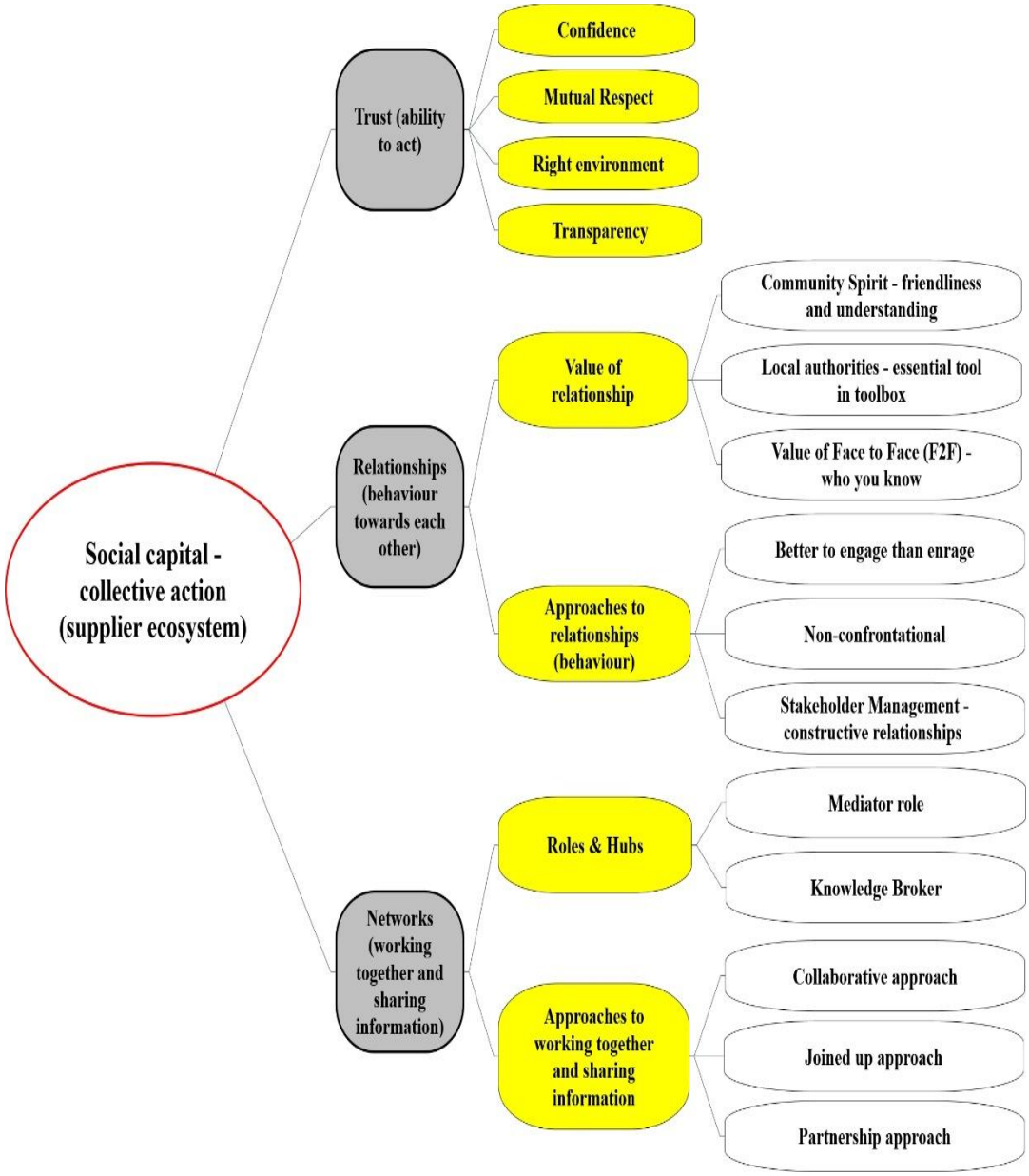
6.4 Exogenous supply ecosystem (SC) – Network-based (RQ1)

The coding results and operational definitions for SC focuses on collective action and identifying the hindrances therein. According to the interviewees (Section 5.4 & 5.7) trust, relationships and networks are CSFs for collective action (Section 5.6.4). Henceforth, each CSF will be analysed separately in the following sections (Section 6.4.1 - 6.4.7).

6.4.1 The value of supply social capital – Collective action

The overall exogenous supply social capital coding is summarised in the following (Figure 6.7). The headings for SC are trust (e.g. the ability to get things done), relationships (e.g. behaviour towards each other) and networks (e.g. working together & sharing information). Each heading will be analysed separately.

Figure 6.7 Supply social capital collective action - coding results



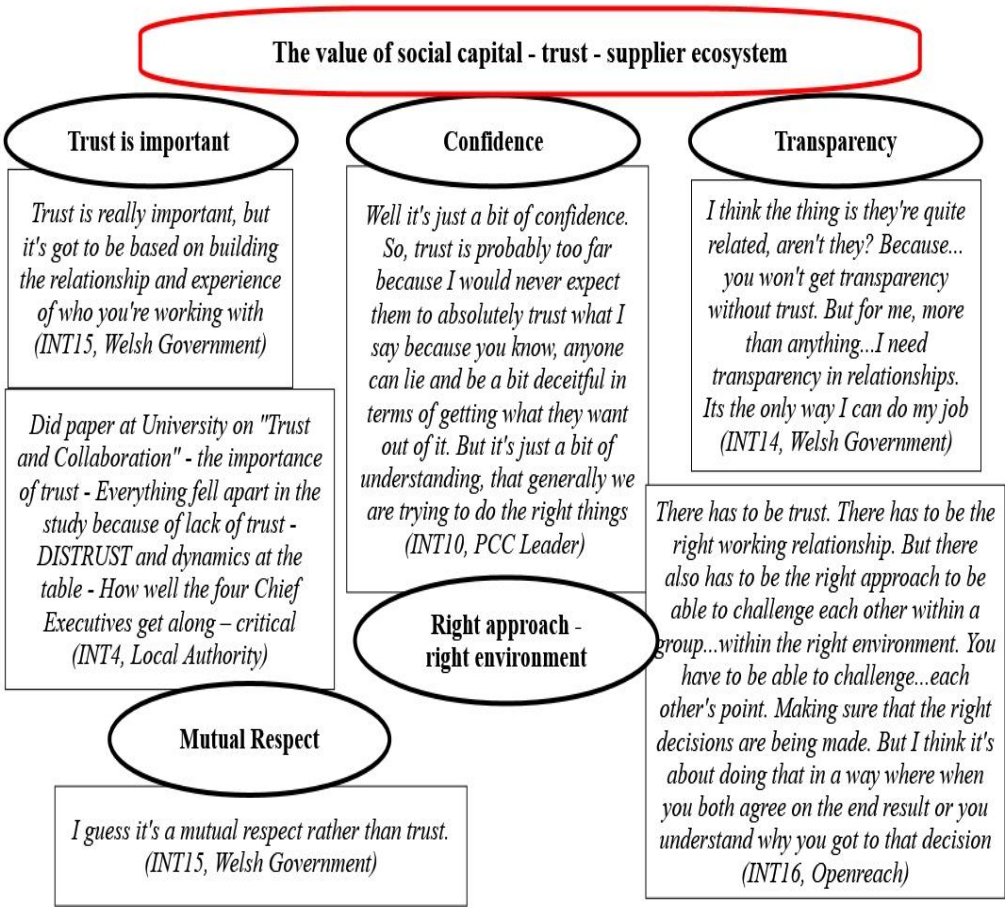
6.4.2 Trust – Different meaning to supply stakeholders (new)

A significant finding and global theme within the supplier ecosystem are the different meanings stakeholders applied to the question about trust (Section 5.4 – 5.6). All recognised trust as an essential component within working relationships but applied different terminology. For example, *confidence* was named instead of trust which is a feeling that you can trust someone or something *to work well* or *behave* as you expect. Confidence was valuable when working with other stakeholders, not necessarily trust, but the actions of others. Confidence in their *ability*, which in turn is about trust (Section 3.6.4). Another respondent expressed *mutual respect*. *Mutual* is to describe

something that is done or felt by all or both people in a group. *Respect* has multiple definitions and can be regarded as a personal attribute (e.g., to admire an *ability* or *good quality*) or a behaviour in relationships (e.g., to treat someone with *kindness & care*). Another respondent related trust to the value of establishing the *right approach and environment* to challenge viewpoints and get to the right decision. Finally, *transparency* was indicated as an imperative to do the job (e.g., activities are done in *an open way* without secrets, so that people can trust that they are *fair & honest*).

Ultimately, all agreed that trust is critical. One notable finding was from a respondent who did a university study on "trust and collaboration" (INT4, Local Authority). INT4 advised the results of the study revealed how vital trust is because distrust amongst chief executives (unit of analysis) destroyed collaborative action. The quotation map for the global theme of trust amongst exogenous supply stakeholders is summarized in (Figure 6.8).

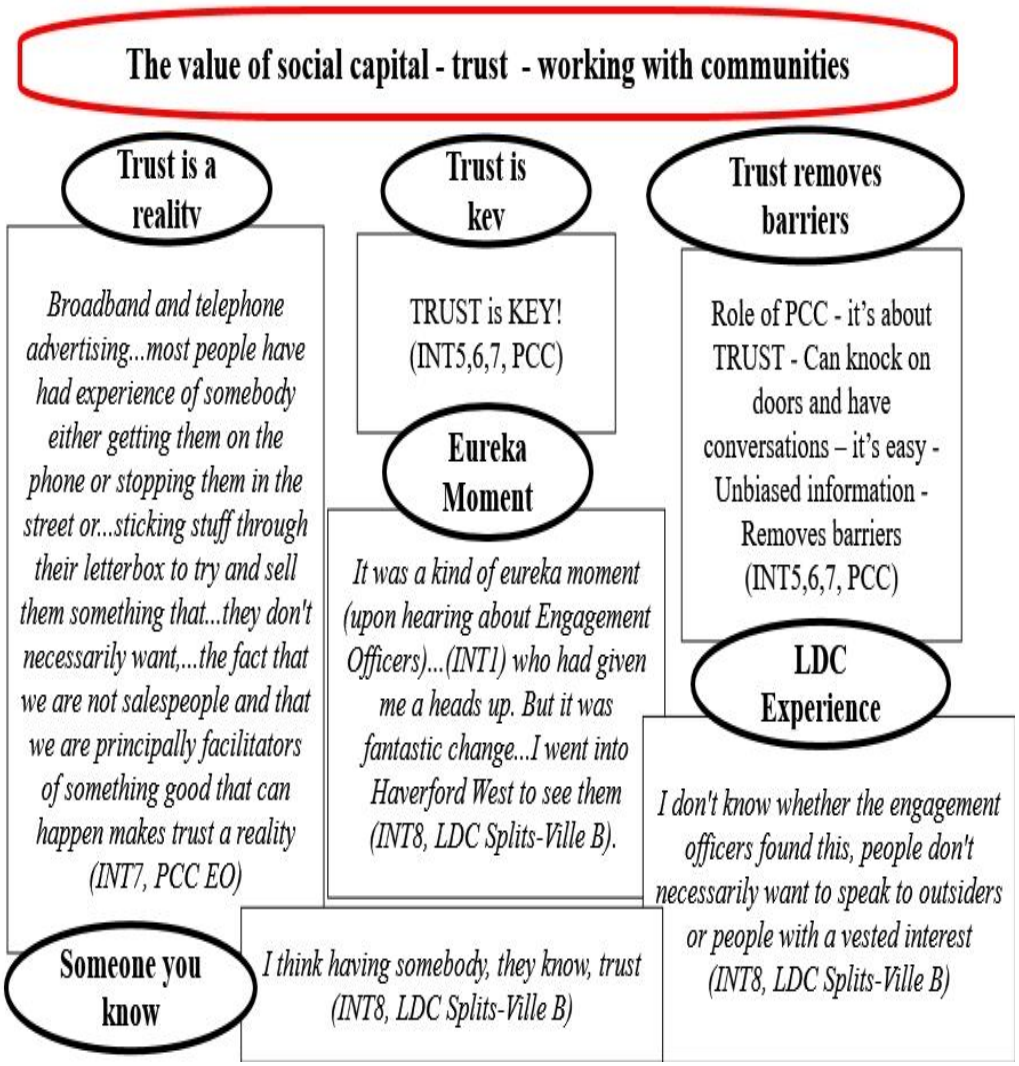
Figure 6.8 Supply social capital - trust - quotation map



6.4.3 Trust is key – Working with communities - CSF

A prominent finding from the PCC initiative identified trust as *key* to working with communities (Section 5.4.3). Local authority representatives, as opposed to commercial suppliers, has engendered trust in working with the PCC to action the pilot project. Rural communities have responded more favorably because of the perceived lack of bias. The findings are summarized in the following (Figure 6.9).

Figure 6.9 Working with rural communities – trust is key - quotation map

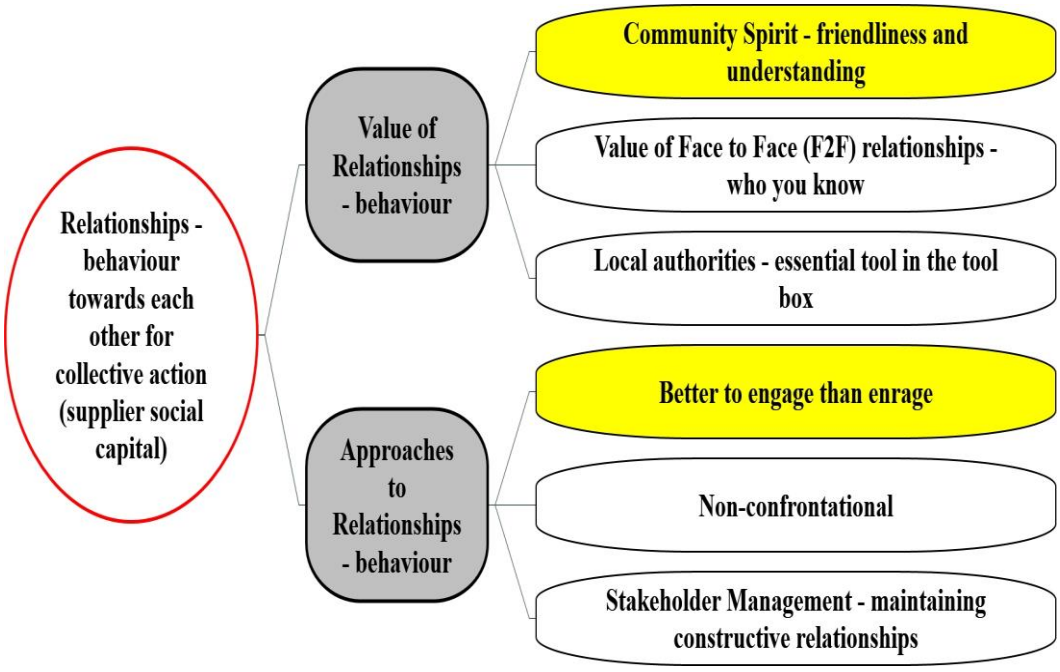


In summary, trust is a significant finding for SC collective action amongst exogenous supply and endogenous demand stakeholders, but also within the approach the PCC leadership have taken when working with rural communities.

6.4.4 Approach to supply relationship - Behaviour – CSF (new)

A summary of the coding results for relationship SC for collective action is presented (Figure 6.10). Relationships are defined as *behaviour* towards each other. Approach is defined as a way of doing something; an *act of communicating* with another person or group in order to *ask for something*. Hence, this section will identify the value of SC relationship (behaviour) and the approaches (communication to get things done) used within the supplier ecosystem for SC collective action to reach the final few.

Figure 6.10 Supply SC relationship behaviour - collective action - coding results



The value of SC relationship behaviour for collective action is identified as Community Spirit, the value of F2F relationships, and the relationship with local authorities is considered an "essential tool in the toolbox" (Section 5.4.1). Community Spirit is defined as *friendliness & understanding* between local people. Hence, friendliness and understanding behaviour is a non-financial value-add.

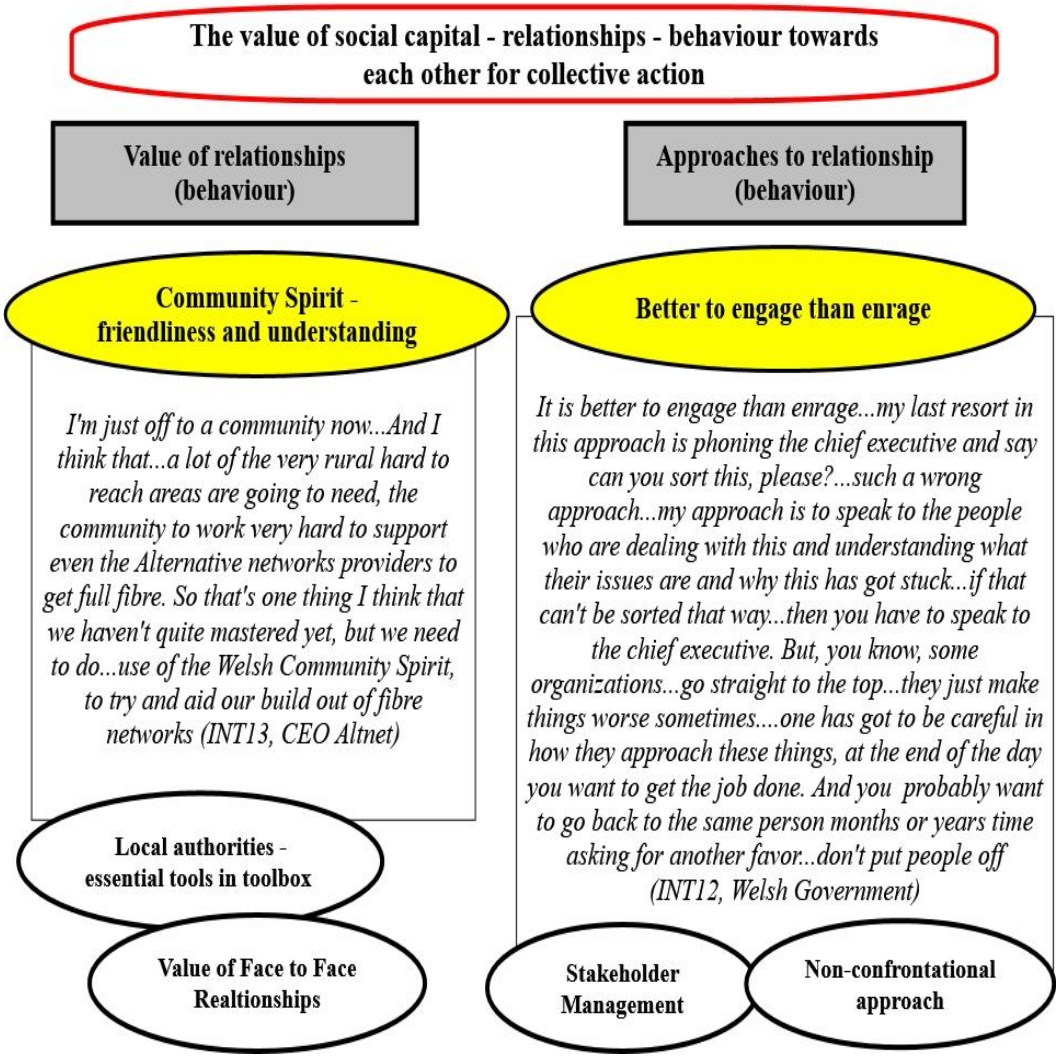
In addition, the SC *approaches* to relationship behaviour were captured (below Figure 6.11) and the non-confrontational approach to maintain relationships and the value of stakeholder management. Confrontation in this context is to cause or involve angry disagreement and thus having an emotional as well as an active factor. Non-confrontational therefore suggests that confrontation is possible, and that some behavioral effort is required by all parties to maintain relationships in a friendly and understanding manner when disagreement over viewpoints is likely. The operational

definition for stakeholder management was edited for this thesis to capture the primary meaning, that the process of forming and *maintaining constructive relationships* helps a business move toward its *stated goals.* Henceforth, how stakeholders' approach, develop and manage ongoing relationships is a non-financial value-add for SC collective action in reaching the final 95k.

6.4.5 Value of supply relationship - Behaviour – CSF (new)

A distinct finding has been the response of the proactive Welsh Government team and how they value SC relationships (behaviour) to get things done and reach the final 95k. One exceptional quotation captures the beneficial ethos of working with stakeholders to achieve long-term goals. It is *"better to engage than enrage"* (INT12, Welsh Government) (Figure 6.11).

Figure 6.11 Supply SC relationship behaviour - collective action - quotation map

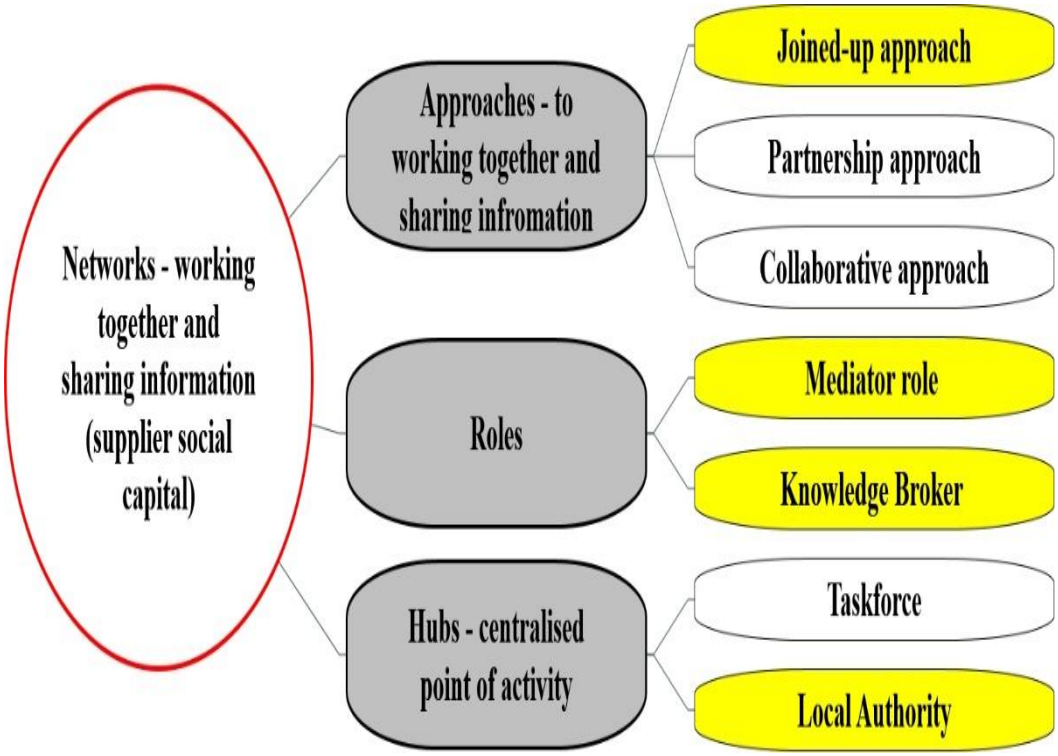


In summary, relationship *behaviour* is necessary for SC collective action. Henceforth, the value of exogenous supplier SC and how they *value* relationship (e.g. capitalising on the Welsh Community Spirit to achieve its goals) and the *approaches* to relationship (e.g. better to engage rather than enrage) stakeholders are valuable assets to getting things done and reaching the final 95k.

6.4.6 Networks – Working together & sharing information

Networks are defined as working together & sharing information. Therefore, network SC is vital to the success of collective action (Section 5.4.5 & 5.6.4). The following (Figure 6.12) presents the SC supply coding results including the approaches to working together & sharing information, and the primary roles to facilitate this process. The value of mediators & knowledge brokers (Section 5.4.2 & 5.4.3). The value of hubs, as a centralised point of activity, was identified as a result of the joined-up approach with the Taskforce Object Connect and local authority engagement (Section 5.11).

Figure 6.12 Supply SC networks - collective action - coding results

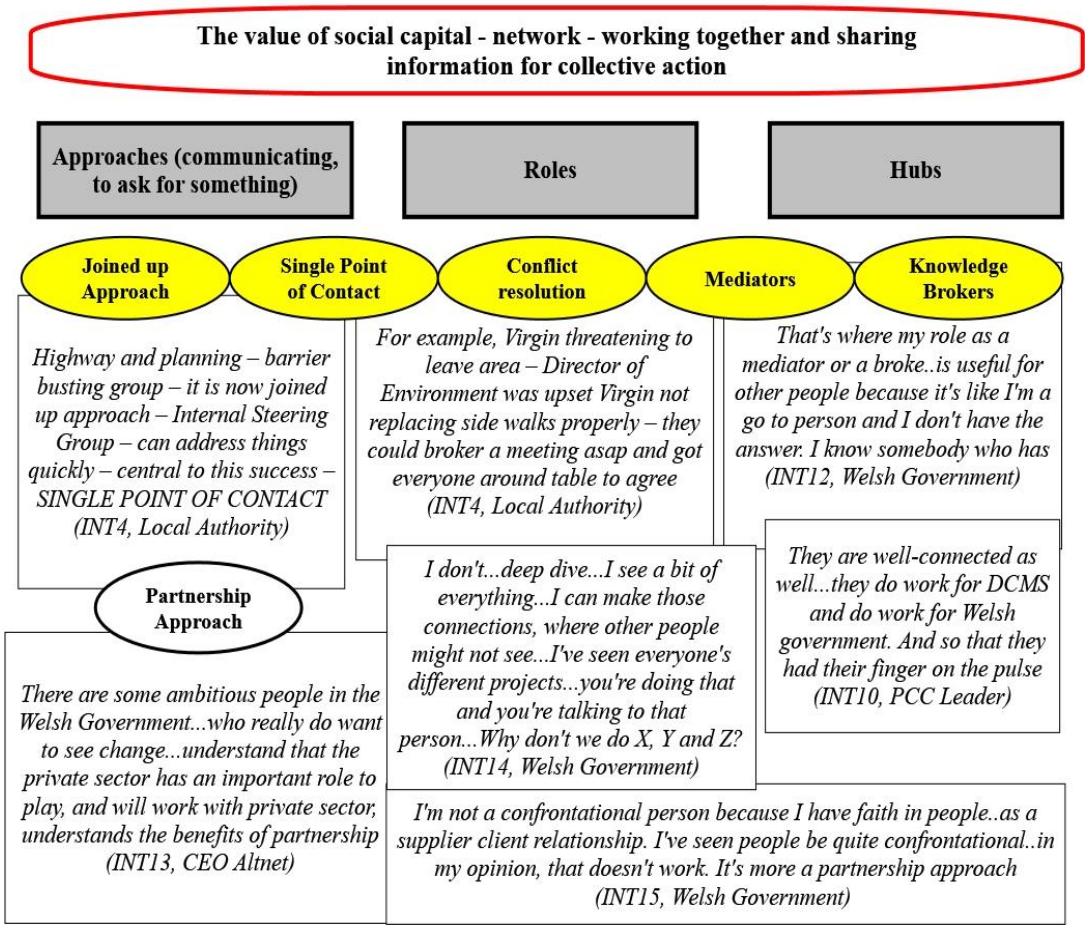


6.4.7 Approaches & value of supply networks – Joined up – CSF (new)

There are several approaches identified by the exogenous supplier ecosystem that facilitate working together & sharing information. The "joined up approach" is the most significant because it reveals the necessity of having *a single point of contact*, particularly for conflict resolution and getting answers more readily for barrier busting challenges (Section 6.3.5). The "partnership approach" is celebrated by Openreach and its desire for strategic partnerships and the benefits partnership can bring (e.g., job opportunities & so forth) (Section 5.6.1 & 5.6.4). Partnership is defined as an agreement between organizations, people and so forth to *work together*.

Collaboration is the act of *working together* with other people or organizations *to create or achieve something* and has been identified by numerous supply stakeholders (Section 5.6.1). The collaborative approach is reminiscent of the value of open innovation (Section 3.7.2) and will be discussed further in potential interventions (Chapter Seven). The following (Figure 6.13) summarises the value of networks.

Figure 6.13 Supply SC networks – collective action - quotation map



6.4.8 Roles (IM) – Mediators & knowledge brokers – CSF (new)

The value of mediators & knowledge brokers within the network cannot be underestimated. Mediators help to end disagreements *by helping the two sides* to talk about and agree on a solution. The mediator role is indispensable for conflict resolution to maintain SC collective action. The mention of mediators suggests that conflict happens and is inevitable. Conflict resolution is an HC people skill thus interweaving both capitals is a non-financial value-add. The operational definition of knowledge broker, created for this thesis, is a person who freely shares both explicit and tacit knowledge for the betterment of others and to enhance SC collective action within the network to reach the final 95k. Thus, the value of innovation management (IM) mediators & knowledge brokers are valuable non-financial capital resources (assets) within this context (Section 5.4 & 6.3.5).

6.4.9 Centralised hubs (IM) – Local authority-level – CSF (new)

The identification of hubs defined as the *central* or main part of something, where there is *most activity*, is a CSF for a "joined up" approach. Knowledge brokers (IM literature) are individuals who act as hubs and who *freely give* information and *connect stakeholders* to one another (Section 5.4). This is a core finding in this thesis. Hubs can be both people (e.g., Mr. G & Mr. P) and organisations (e.g., anchor institutions, Taskforce & local authorities).

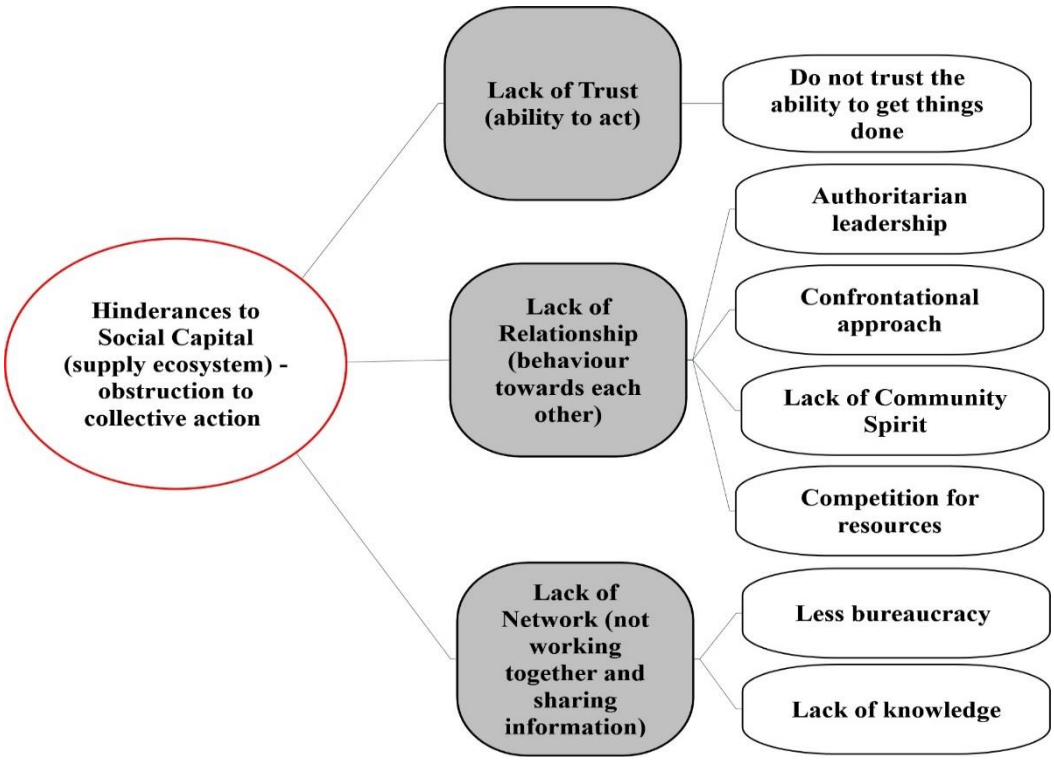
In summary, the value of HC & SC within exogenous supply networks cannot be underrated. The joined-up approach supports sharing information and knowledge flow. The value of mediators & knowledge brokers (IM) to facilitate communication, conflict resolution and knowledge flow. The role of hubs (IM) to act as centralized point of contact (e.g., barrier busting, best practice & networking) and centralized repositories (e.g., knowledge capture & dissemination). More specifically, the identification and incorporation of IM literature concepts adds terminology and new thinking to rural broadband analysis. Further synthesis of the significant findings will be detailed in potential interventions (Chapter Seven).

6.4.10 Hindrances to supply social capital collective action (network-based)

Barriers or hindrances to SC that obstruct collective action have been identified as the lack of trust (or no ability to get things done), lack of relationship (or counterproductive or negative behaviour towards each other), and the lack of networks

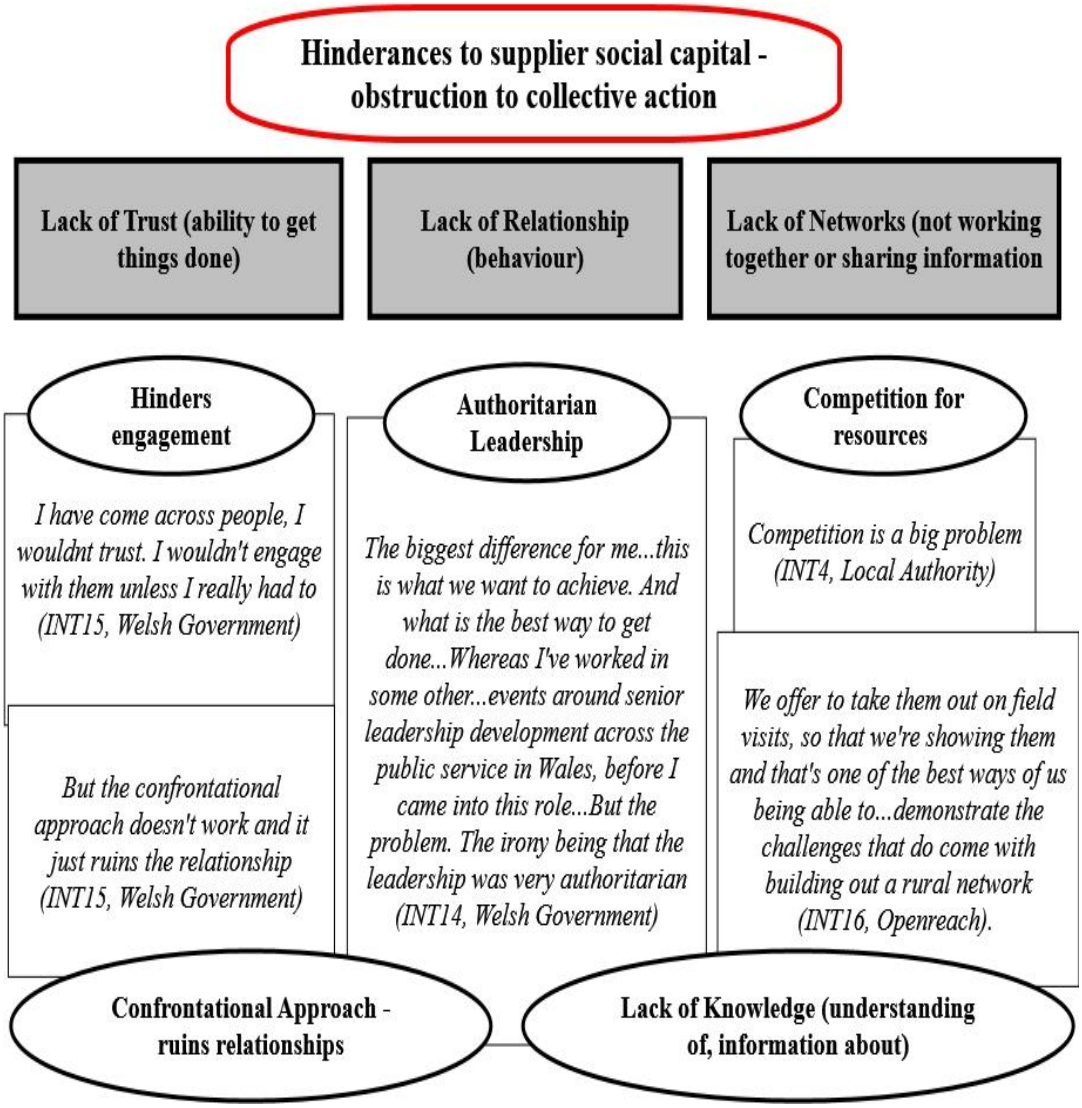
(or not working together & sharing information). The following diagram reveals details from the supplier participants viewpoints that obstruct the flow of SC collective action (Figure 6.14).

Figure 6.14 Hindrances to supply social capital collective action - coding results



The majority of these findings were explained in (Section 5.4.1). However, a summarised quotation map is provided in the following (Figure 6.15). Authoritarian is defined as demanding that people obey completely and *refusing to allow them freedom to act* as they wish (barrier). Bureaucracy is defined as a workplace with complicated rules, processes, and written work that *make it hard to get something done* (hindrance). Confrontation was previously defined as angry disagreement. Competition is defined as a situation in which someone is trying to win something or be more successful than someone else, hence competition for resources can be counterproductive to SC collective action. Lack of Community Spirit can be defined as unfriendly and unsympathetic towards collective action. This finding is in stark contrast to the empowering HC leadership approach identified in (Section 5.4.1 & 6.3.2). Bringing together all of these findings, a picture emerges amongst respondents that authoritarian or dictatorial leadership that does not empower individuals and too much bureaucracy restricts the freedom of people and relationships to get things done and reach the final few.

Figure 6.15 Hindrances to supply SC collective action - quotation map



To conclude, key words to supply SC collective action include ability, actions, care, confidence, kindness, mutual respect, open, right environment, transparent, work well together (trust). Local authority as an essential tool, friendliness, understanding and value of F2F (relationship behaviour). Better to engage than enrage, non-confrontational, maintaining relationships (approaches to relationship). Freely share explicit and tacit knowledge, most activity (network people & roles). Achieve, act of communicating, ask for something, collaborative, partnership, working together (network approaches). Hindrances to SC collective action is making it hard to get things done, no freedom and unfriendly (authoritarian, bureaucratic, lack of Community Spirit).

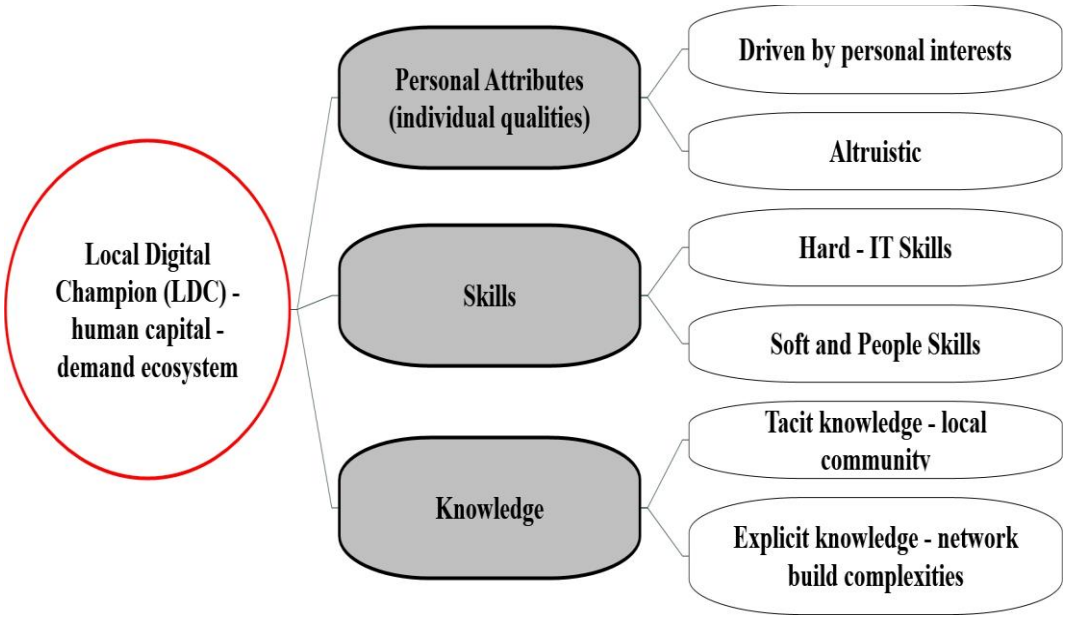
6.5 Endogenous demand ecosystem (HC) – Place-based (RQ1)

The demand ecosystem combines both place-based (rural community) and network-based (engagement with supply ecosystem). The value therefore of demand HC productivity & SC collective action are addressed in this section.

6.5.1 The value of demand human capital - Productivity

The local digital champions (LDC) are CSFs to human capital productivity & social capital collective action. If Mr.G (LDC, SV-A) had not acted on behalf of the community by utilising his individual HC & SC, both place-based (within the demand ecosystem) and network-based (within the supply ecosystem), then SV-A would still be waiting for SFBB (Section 5.8.1). The following (Figure 6.16) summarises the LDC human capital for SV-A and B.

Figure 6.16 Demand ecosystem – Local digital champion HC – coding results



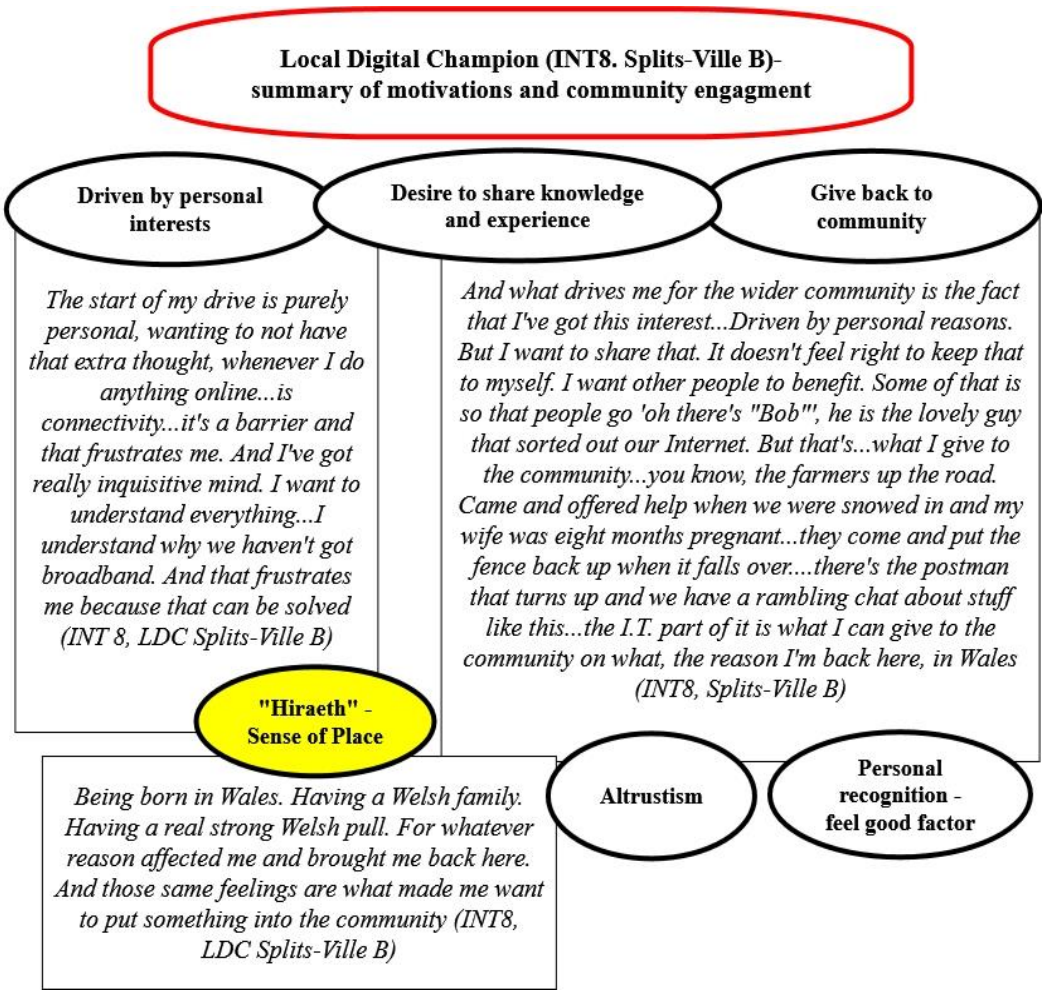
6.5.2 Local digital champions (LDC) – CSF

As explained (Section 5.8), a primary finding in the demand ecosystem, which confirms previous rural broadband studies (Section 3.5), is the motivation of the LDCs as a CSF. The value of LDC HC productivity for Splits-Ville are notable. Both LDCs (INT1 & 8) expressed similar motivations (Section 5.8.1 & 5.8.2). Partly self-interest to access reliable broadband for themselves, but also altruistic and a sense of place to give back to the community.

6.5.3 Altruism (new) & sense of place "hiraeth"

Altruism is defined as showing a wish *to help* or bring advantages to others, even if it results in disadvantage for yourself. The non-financial value-add of this personal attribute is identified by the EOs as part of the spectrum of human behaviour when identifying assets within the community (Section 5.4.3). In addition, the Welsh word "hiraeth", infers a homesickness, longing or a "sense of place". The sense of place identified in the rural broadband literature (Section 3.5) is considered a CSF for resilience. Finally, both LDCs admitted to the "feel good factor" of having accomplished the goal and supporting the community by investing their IT skills to help others, but not without a cost. The feelings of "guilt" or not connecting adjacent areas weighed heavily on both LDCs because they felt it was their responsibility to "fix it" for every rural resident, even though it is a difficult task for them to undertake as volunteers. The following (Figure 6.17) summarises these motivations.

Figure 6.17 LDC (Splits-Ville B) – motivations - quotation map



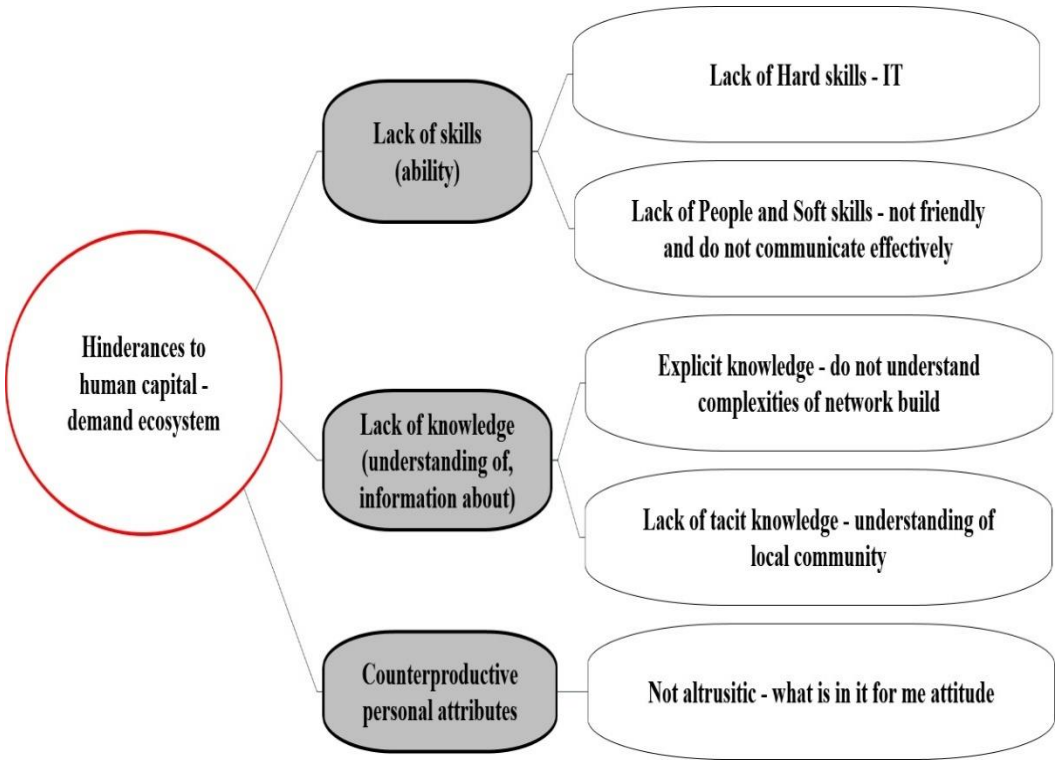
6.5.4 Hard, soft skills & local tacit knowledge

Hard IT skills and the value of people & soft skills was identified as CSFs for getting SFBB to SV-A (Section 5.8). The LDCs expert IT skills and local tacit knowledge is an essential "tool in the toolbox" for local authorities and commercial suppliers. In brief, the value of HC & SC contributions of the LDCs is rich and deeply embedded in the community. Governments and commercial suppliers will do well to value these non-financial assets as capital resources.

6.5.5 Hindrances to demand human capital productivity (place-based)

Most of the positive attributes were identified in (Section 5.4.3) and the experience of the EOs and Openreach CFP when working with communities (Section 5.6.1). Henceforth, this section interweaves the hindrances to HC productivity in the exogenous supply ecosystem, but also the failure of not having an LDC within the demand ecosystem. A summary of the hindrances to demand HC productivity is presented in (Figure 6.18).

Figure 6.18 Hindrances to demand human capital productivity - coding results



In brief, the lack of skills, knowledge and counterproductive personal attributes will hinder HC productivity in the demand ecosystem and should be identified and mitigated to reach the final 95k.

To conclude, key words to endogenous demand HC productivity includes ability, champions, driven by personal interests, feel good factor, to help even when at disadvantage to oneself and sense of place (personal attributes). Friendly, communication and IT (skills & knowledge). Hindrances to HC demand productivity is to not communicate effectively, not understand the complexities of network build, lack IT skills, not altruistic or friendly (counterproductive attributes, skills & knowledge).

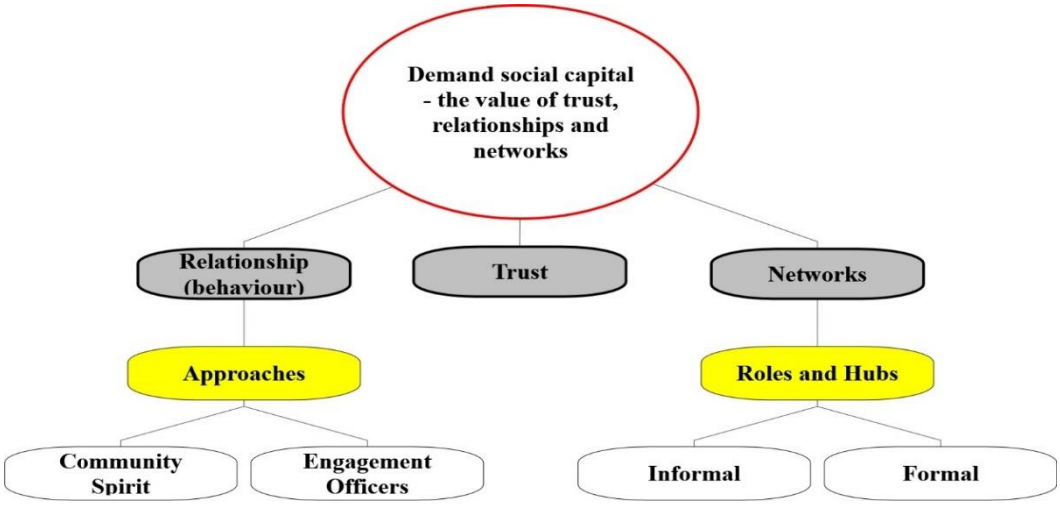
6.6. Endogenous demand ecosystem (SC) – Place-based (RQ1)

Formal SC (related to the supply ecosystem) and informal SC (place-based in the rural hamlet) are valuable assets within both ecosystems (Section 5.8) for collective action to reach the final 95k. The following section summarises the value of demand SC (Figure 6.19) and the hindrances therein (Figure 6.20).

6.6.1 The value of demand social capital – Collective action

Demand social capital relies on trust (e.g. with commercial supplier, local authority & local community), relationship behaviour (e.g. Community Spirit & EOs) and networks (e.g. formal & informal). The individual value of the LDCs HC productivity & SC collective action for Splits-Ville has been identified (Section 5.8.1). Moreover, the local community trust for the EOs is a CSF (Section 5.4.3). The lack of trust thereof with Openreach and Altnets are hinderances to SC collective action within the demand ecosystem (see below Figure 6.20). The following demand SC for collective action is summarised in (Figure 6.19).

Figure 6.19 Demand SC- trust, relationships, networks - coding results



6.6.2 Trust, mediators & knowledge brokers (IM) – CSF (new)

Trust was identified as CSF and key to rural community engagement (Section 5.4.3 & 6.4.2). The IM role of mediator & knowledge broker are CSFs (Section 6.4.5). It was "who you know & what you know" and the F2F relationships that Mr. G (Section 5.8.1) built within the supply ecosystem that contributed to the success of acquiring SFBB for SV-A (formal networks). It was also the value of Mr. G's HC & SC that benefitted the community (informal networks). The introduction of the EOs approach and the value of local Community Spirit for friendly interaction to achieve the goals is noteworthy. All of these factors were discussed in (Section 5.4.3, 5.8.1 & 5.8.2) and considered place-based CSFs in reaching the final few.

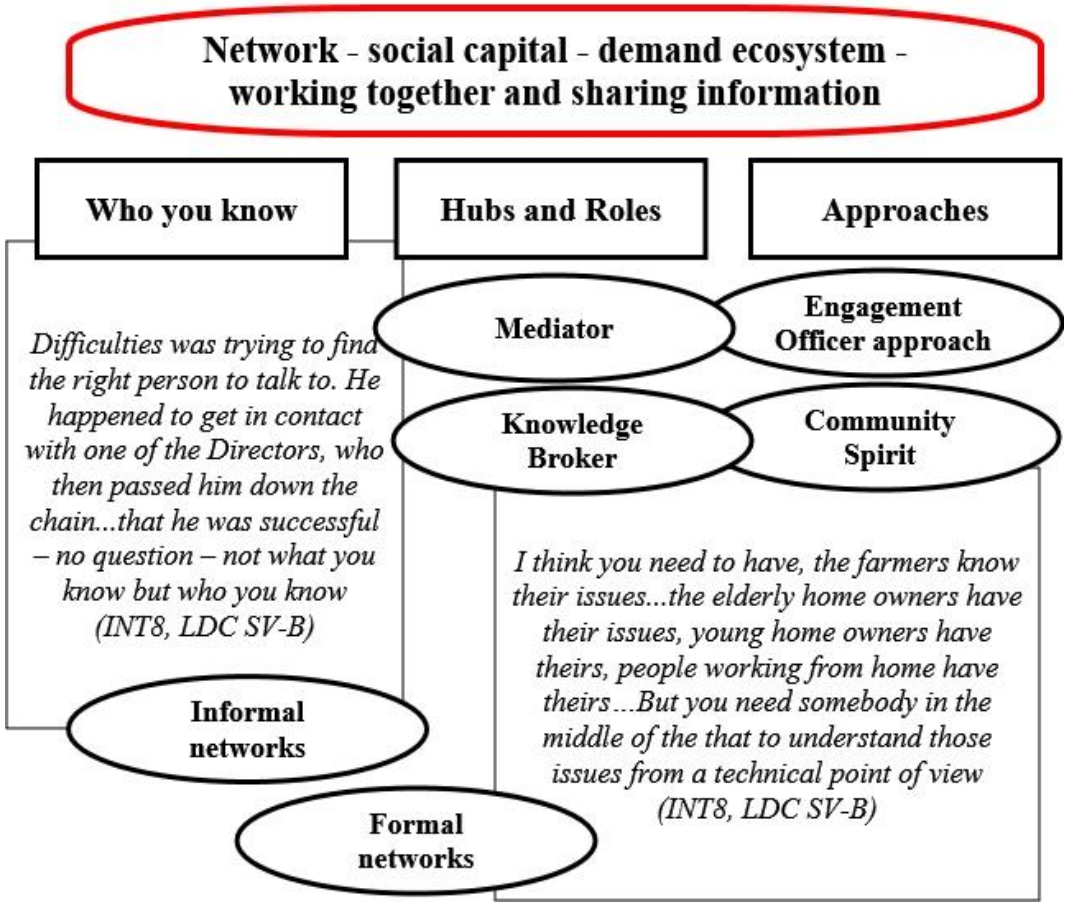
6.6.3 Value of local relationship behaviour - Community Spirit – CSF (new)

Community Spirit was identified in the RSCAT as a CSF (Section 5.8.4, Figure 5.29) and as an asset for Openreach and Altnets to engage with the demand ecosystem (Section 6.4.4, Figure 6.10). Community Spirit was defined above and thus a non-financial value-add when dealing within both ecosystems.

6.6.4 Value of local networks – Informal & formal – CSF (new)

Informal social capital networks was identified in the RSCAT for rural hamlets (e.g. 20 properties) as a CSF (Section 5.8.4, Figure 5.29). Networks was defined as working together & sharing information. Informal SC networks therefore are valuable when dealing with local communities to work together and share information. This was evidenced in the free word of mouth advertising for the EO supply ecosystem project (Section 5.4.2). In addition, the LDCs formal and informal SC networks within both supply and demand resulted in the successful implementation of SFBB (SV-A). Hence, these are additional non-financial value contributions for SC collective action (Figure 6.20).

Figure 6.20 Demand SC network – collective action - quotation map

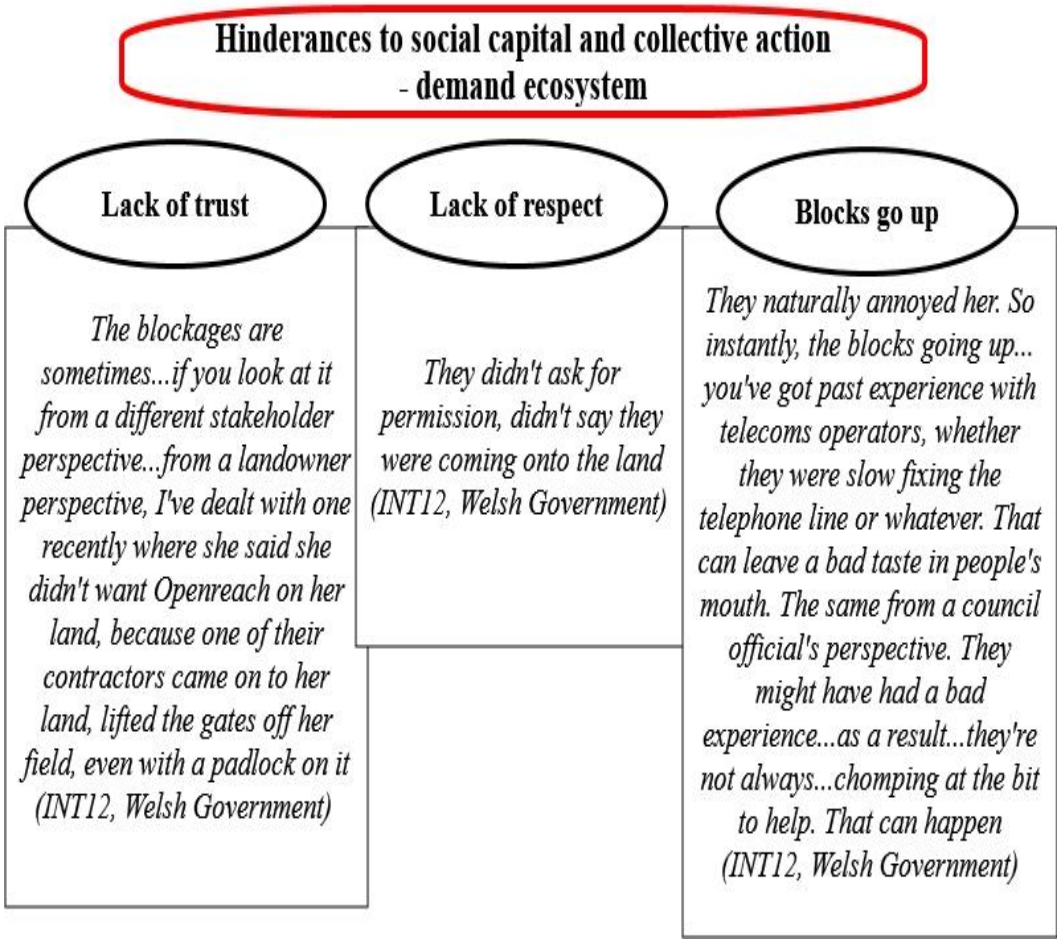


In sum, the non-financial capital value of trust, mediators, knowledge brokers, Community Spirit, informal and formal networks all contribute to SC collective action to reach the final 95k.

6.6.5 Hindrances to demand social capital collective action (place-based)

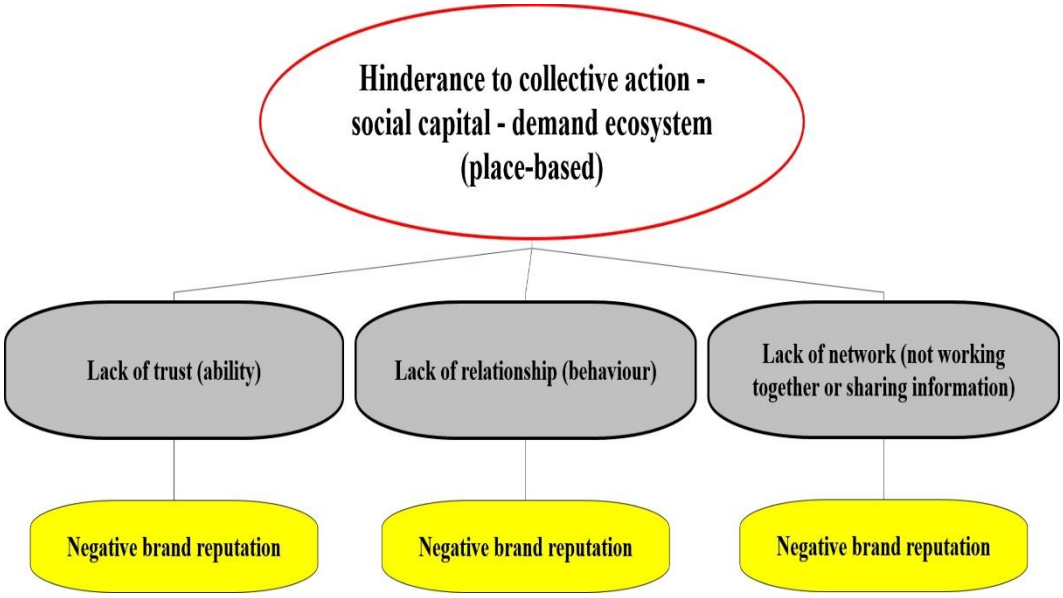
Barriers and hindrances to SC collective action within the demand ecosystem are the converse of the positive SC attributes. The lack of trust (or distrust) landowners expressed when Openreach entered their field without permission (Figure 6.21). The lack of relationship (e.g. counterproductive behaviour or lack of mutual respect) provides the impetus for distrust and negative brand reputation local communities have for commercial suppliers. This finding corroborates the negative experiences of the Connecting Cumbria case study discussed in (Section 3.5.1). The lack of network is exhibited by Openreach when not working together & sharing information with the LDC which resulted in an unnecessary six-month delay in getting SFBB to SV-A (Section 5.8.1) and when upsetting local landowners (Figure 6.21).

Figure 6.21 Hindrances to demand SC collective action – quotation map



Furthermore, as INT17 (PCC, EO) explained, the EOs can become the object of anger and frustration if the local authority or commercial suppliers fail to achieve full fibre connectivity in the pilot project areas (Section 5.4.3). Henceforth, the unwillingness of commercial suppliers and governmental bodies to recognise the value of trust, relationships and networks, can negatively impact place-based SC for collective action. The following figure summarises hindrances to SC collective action in the endogenous demand ecosystem (Figure 6.22).

Figure 6.22 Hindrances to demand SC collective action- coding results



In summary, governmental and commercial suppliers will do well to value the place-based demand social capital. By not recognising the value of these capital resources, can result in hindrances and obstructions to collective action to reach the final few. Thus, hindrances to endogenous demand SC should be addressed and mitigated where possible.

To conclude, key words to endogenous demand SC collective action include ability, F2F, friendly interaction to achieve goals, formally and informally sharing information and working together and who you know (trust, relationships & networks). Hindrances to demand SC for collective action includes counterproductive behaviour, distrust, lack of sharing information or working together.

6.7 Summary of capital contributions (RQ1)

In summary, the value of capital resources, both financial and non-financial, are clearly evidenced to answer RQ1. The value of HC productivity & SC collective action within both complex ecosystems can be viewed as tangible assets in resolving the digital divide. Shared financial capital (SFC), reviewed in the following section, involves multiple opportunities for all stakeholders to reach the final 95k. Environmental capital (EC) was summarised in (Section 5.10.4 & 6.2). The following section investigates the mutual learning and cooperative interplay opportunities within these complex ecosystems.

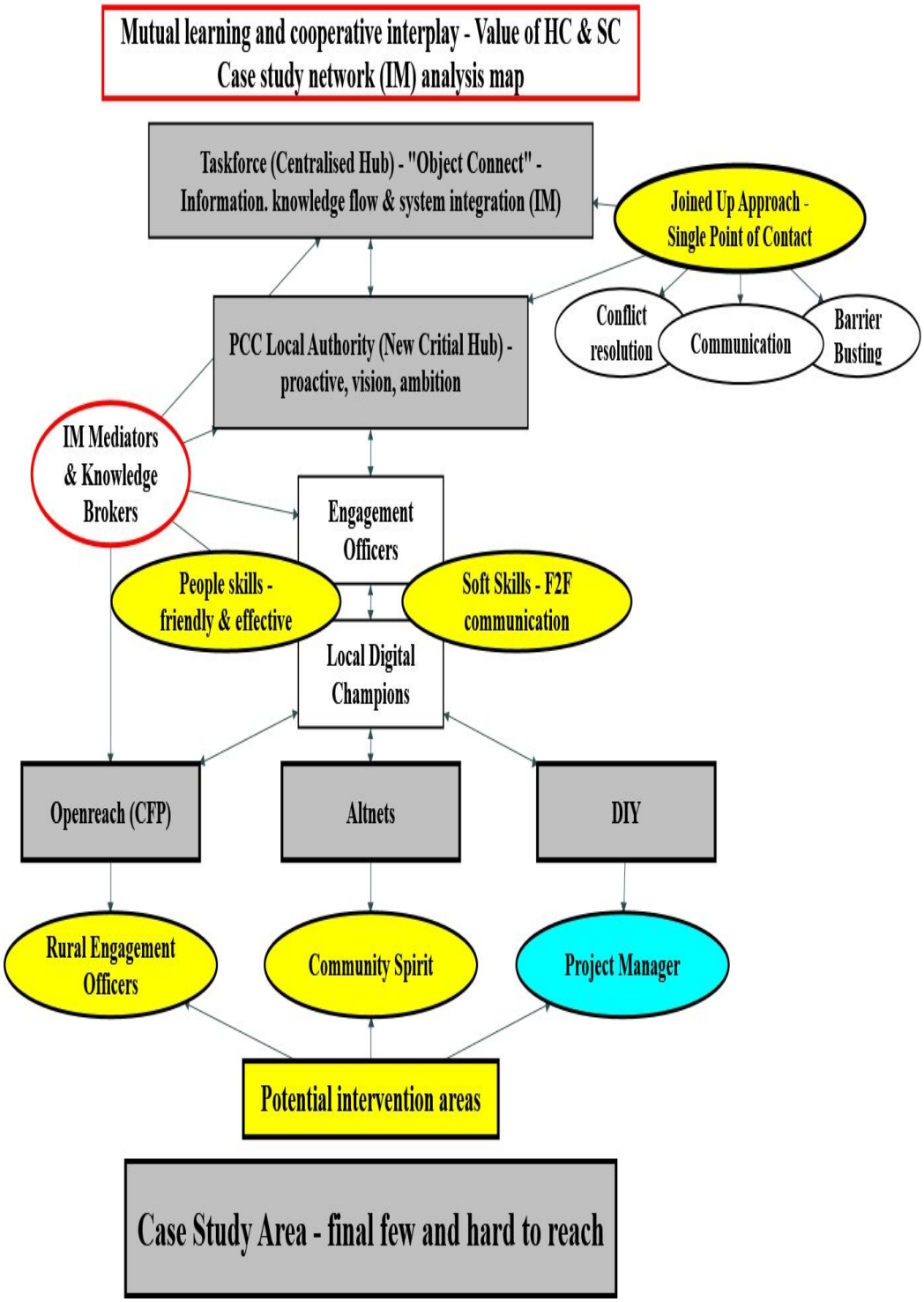
6.8 Complex ecosystems – Mutual learning & cooperative interplay (RQ2)

The summary evidence presented within the complex ecosystems in (Section 5.11) reveal multi-capital, multi-stakeholder mutual learning and cooperative interplay opportunities to answer (RQ2). This section sets out to answer RQ2 using network analysis maps that illustrate the findings and interrelationships between human, social capital and innovation (IM) analysis (Section 6.8.1). Developing upon this, Section 6.8.2 brings together the findings on shared financial capital and the collaboration required to utilise this effectively. Together these sections provide the initial answer to RQ2: how can multiple stakeholders in both supply and demand ecosystems mutually learn and collaborate to resolve this complex rural digital divide challenge?

6.8.1 Human & social capital – IM network analysis (top-down approach)

The Splits-Ville case study network analysis map is intended to be a summarised diagram to illustrate how the HC, SC and IM findings move from the Taskforce (centralised hub), through the local authority (new critical hub), into the EOs and ideally to the LDCs and commercial suppliers (Figure 6.23). The diagram incorporates IM analysis by showcasing how information and knowledge flows, the value of local/product champions, potential appropriability resolution through non-financial capital appreciation and the value of a fifth-generation "systems integration & networking" approach (Section 3.7.1). The following diagram (Figure 6.23) is meant to capture and visualise some of the findings. More detailed applications of the findings will be discussed in (Chapter Seven). The diagram is explained below (Figure 6.23).

Figure 6.23 HC, SC & IM analysis - mutual learning & cooperative interplay



The diagram illustrates that the mutual learning & cooperative interplay opportunities (hereafter referred to as ML & CI) are numerous if both ecosystems recognise the value of HC productivity, SC collective action and IM analysis.

The Taskforce (Section 5.4.1) is a newly formed centralised hub (IM) to coordinate stakeholders and information knowledge flow at **local authority-level** (Section 6.4.9). The ML & CI is evidenced and described in the "Object Connect" (central repository) to create a joined-up approach and single point of contact for barrier busting, communication and conflict resolution (e.g. HC & SC engagement). This joined up approach can help activate the opportunities and resolve the barriers identified in (Sections 5.2, 5.4, 6.4.6 & 6.4.7 – 6.4.9). This means that local authorities can meet face-to-face (F2F) with other colleagues, coordinate barrier busting activities, share best practice and in doing so mutually learn and cooperate to reach the final few at the local authority-level. The identified role of IM mediators & knowledge brokers is a CSF for information and knowledge flow throughout both ecosystem-networks to capitalise on opportunities and resolve barriers/hindrances in reaching the final few (Section 6.4.8).

Additional factors to increase the success of interventions include resolving the pressures of time-bound contracts and adopting State Aid flexibility. An opportunity was also identified for local authority intervention to include the stranded assets (Section 5.4.1.3) in their planning and capitalise on the clawback clause in order to finance activities (Section 5.4.1.3.5). Specific potential intervention areas have been identified and will be discussed in (Chapter Seven). The summarised SFC opportunities will be explained specifically in (Section 6.8.2).

The PCC Local Authority (Section 5.4.2) is a new critical hub (IM) and a focus for activity to reach the final few (Section 5.4.1 – 5.4.6). The ML & CI includes the proactive leadership (HC) and teamwork (SC) to develop and manage stakeholder relationships to get the job done (Section 5.4.2.1 – 5.4.2.3, 6.3.2, 6.3.3, 6.4.7). More specifically, the newly stated PCC 70% demand/take-up statistic and the relationship feedback loops with DCMS, and the Welsh Government could encourage further investment (Section 5.4.2.4 & 5.4.2.5).

The Engagement Officers (EOs) (Section 5.4.3) ML & CI can capitalise on the local tacit knowledge (HC) of the spectrum of human behaviour by identifying altruistic volunteers from which to build trust, partnerships and share information and knowledge across the networks (Section 5.4.3.1, 5.4.3.2, 6.4.2 - 6.3.4). The value of the EOs use of HC people & soft skills when working F2F with the community and

identifying LDCs is a non-financial value-add and strategic imperative when financial resources are constrained (Section 5.4.3.2, 6.3.4 - 6.3.6). The EOs are now IM mediators & knowledge brokers for the rural community, local authority and commercial suppliers (Section 6.4.8). These findings can aid the appropriability conundrum if stakeholders appreciate the non-financial value-add these types of HC-SC skills and roles contribute (Section 3.7).

The Local Digital Champion (LDC) (Section 5.8.2 & 5.8.3) findings show that ML & CI can benefit local authorities and commercial suppliers if they avail themselves of the rich and altruistic non-financial value-add of the HC-SC therein (Section 6.5 & 6.6). The value of LDCs as IM mediators & knowledge brokers should not be underestimated (6.6.2). Moreover, the value of SC informal networks and the friendliness and understanding of rural Welsh Community Spirit are further non-financial assets (Section 6.6.3 & 6.6.4) which can be capitalised on for free word-of-mouth advertising (Section 5.4.2). Potential intervention areas have been identified and will be discussed in (Chapter Seven).

Commercial and Altnet supplier (Section 5.6) ML & CI collaborative and partnership opportunities are numerous (Section 5.6.1 – 5.6.4). The improved Openreach investment in HC-SC roles (e.g. Director of Partnerships & Rural Engagement Officers (REOs)) should provide additional IM support at the local-authority and rural community-level (Section 5.6.2). SFC opportunities are abundant (Section 5.6.5 – 5.6.7) and will be explained below (Section 6.8.2). More specifically, the improved collaboration between Openreach and Altnets, particularly through new DPS at local-authority level, is another new opportunity to explore (Section 5.6.3, 5.6.4 & 5.6.7). Potential intervention areas have been identified and will be discussed in (Chapter Seven).

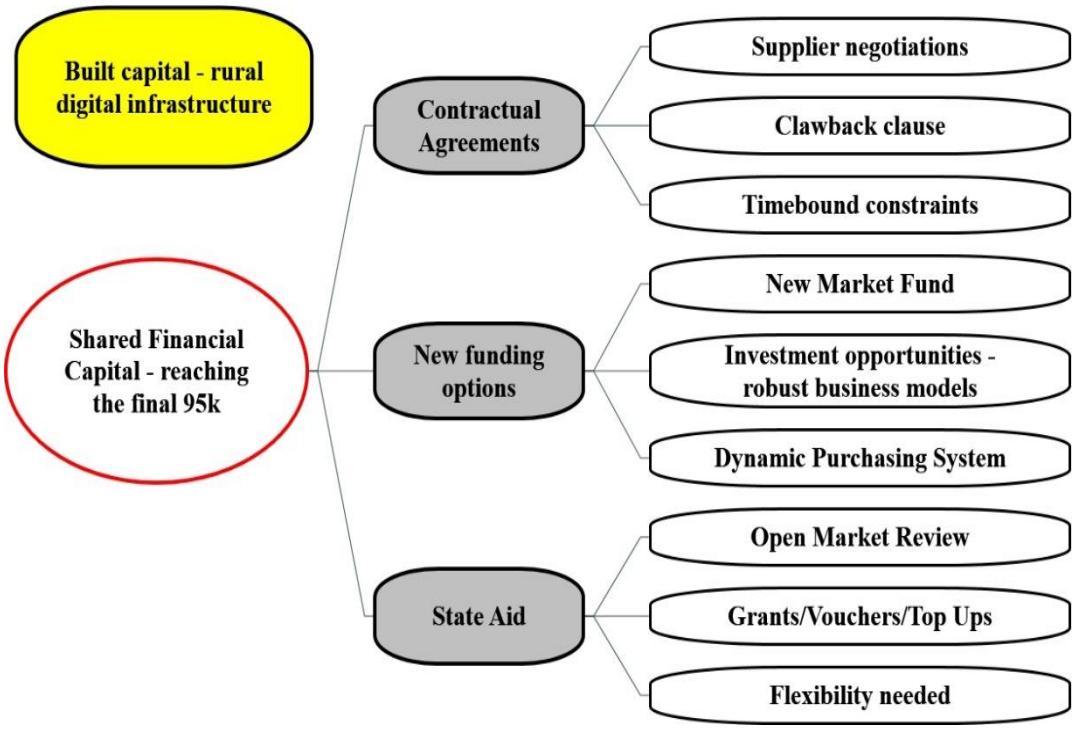
Rural community Do-It-Yourself (DIY) (Section 5.4.4) resides in the value of the HC-SC local networks. Local DIY initiatives have multiple ML & CI opportunities with four-fold capital inputs and outputs (Section 5.10.2.4 – 5.10.2.6). One notable opportunity (or gap) to assist rural DIY options is the potential funding of a "Project Manager-type" role as suggested in (Section 6.3.7). Potential intervention areas have been identified and will be discussed in (Chapter Seven).

In summary, the identification of the "joined up" approach as a central repository is considered a CSF for conflict resolution within the supply ecosystem (Section 5.4 & 6.4.7). The HC (people & soft skills) identified primarily for the EOs and LDCs (Section 5.4.3 & 5.8) are equally present in the Taskforce and PCC delivery teams (Section 6.3.5 & 6.5.4). Moreover, the identification of IM mediators & knowledge brokers are considered CSFs throughout both supply and demand ecosystems (Section 6.4.5 & 6.6.2). The new commercial and Altnet supplier opportunities resides in new rural community-level roles (e.g. REO & potential DIY Project Manager) and the non-financial SC value of Community Spirit from which to partner. Henceforth, this network analysis is intended only to give a snapshot of how some of the HC, SC and IM findings for mutual learning and cooperative interplay flows into and out of the case study area. The application and potential intervention opportunities will be discussed in (Chapter Seven).

6.8.2 Shared financial capital – Mutual learning & cooperative interplay

Another outstanding opportunity for both complex ecosystems is how the shared financial capital (SFC) is evolving to reach the final 95k. The SFC coding map summarises these findings to develop the built capital for rural digital infrastructure (Figure 6.24).

Figure 6.24 Shared financial capital - built rural capital - coding results



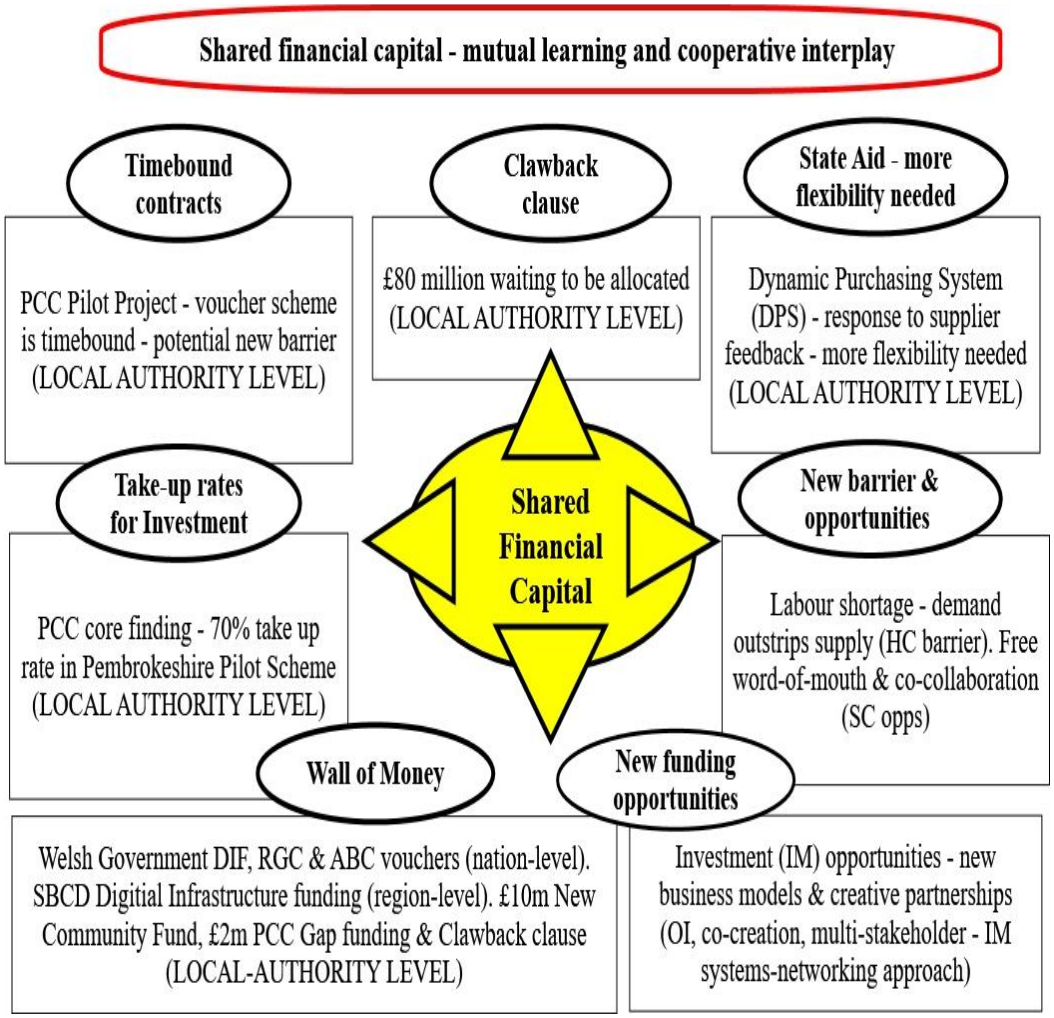
The SFC opportunities and benefits derived from (Section 5.11) identified several mutual learning and cooperative interplays (e.g. more flexibility with State Aid & new funding opportunities at the local authority-level). One outstanding discovery identified the challenges with stranded assets and time-bound contracts (Section 5.4.1.3 & 5.5.1). The time-bound constraints were not only evidenced in the legacy Superfast Cymru contracts, but also in the present voucher scheme on which the PCC Pilot Schemes rely (Section 5.4.3). These timebound constraints could hinder the PCC initiative if delays play against them.

Conversely, there are multiple opportunities being presented with the allocation of the clawback funds, the 70% take-up rate in Pembrokeshire, the flexibility of the new Dynamic Purchasing System (DPS) and the Wall of Money to inspire investment in these remote rural areas (Section 5.4.1.3.4, 5.4.2.4, 5.6.5 & 5.6.7). All of these initiatives are at the **local authority-level**. This is a core finding of this research. Multiple national, regional and specifically local authority-level funding opportunities have been identified (Figure 6.25).

Moreover, all of these initiatives are promising but may be constrained by a newly identified barrier. Currently, demand is outstripping supply, and an HC labour shortage constrains the network build (Section 5.5.2). However, numerous IM collaboration and partnership opportunities have been identified (5.6.1, 5.6.2, 5.6.3 & 5.6.4) and will be discussed further in (Chapter Seven).

In addition, if the Welsh Government can procure the relevant investment HC skills required to manage a new Digital Infrastructure Investment Fund (DIIF) this could add another layer for SFC to reach the final 95k (Section 5.2.1). In brief, the following figure summarises the SFC findings and mutual learning and cooperative interplay opportunities to answer RQ2 (Figure 6.25).

Figure 6.25 Shared financial capital - mutual learning & cooperative interplay

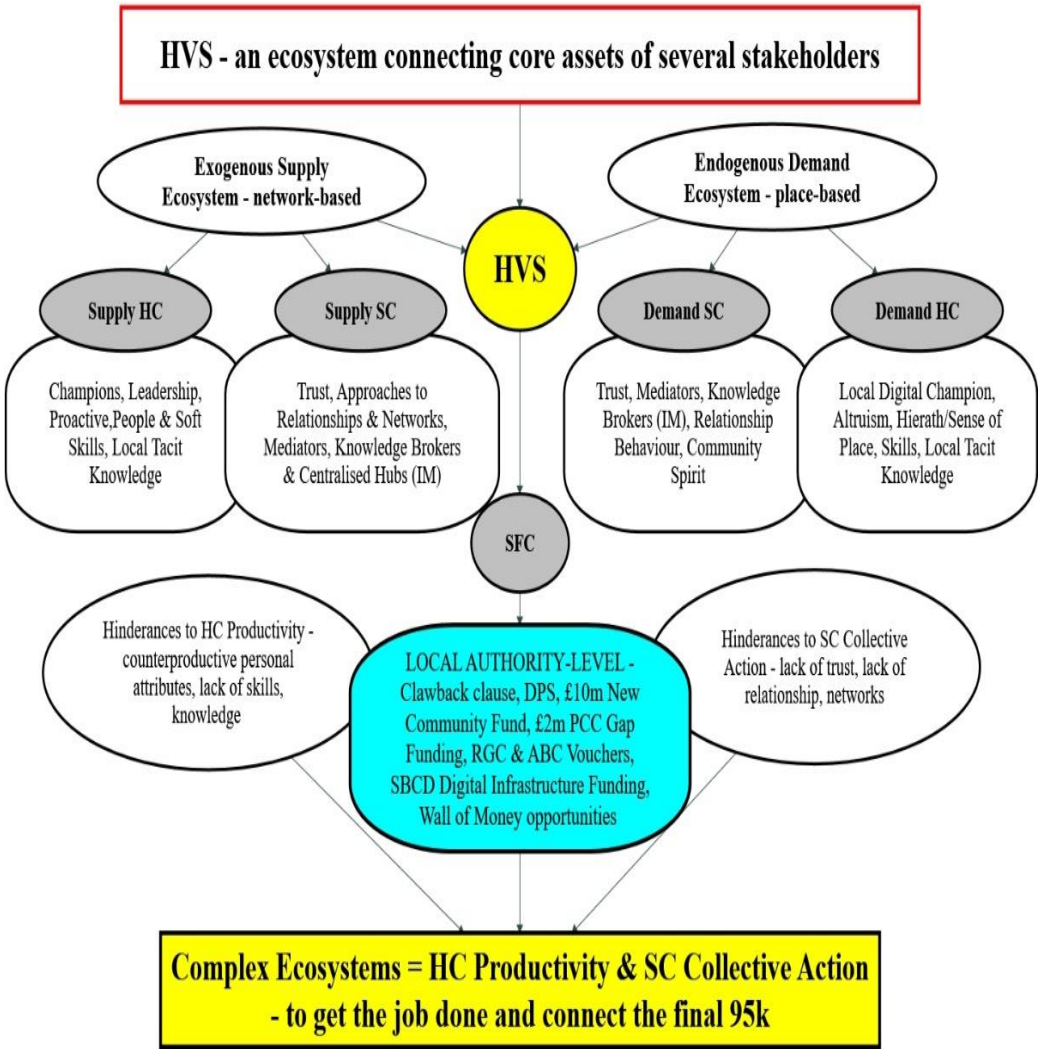


To conclude, the new funding opportunities at the local authority-level are a key finding of this research. The clawback clause is a major opportunity for local authorities but it not being capitalised upon or decisively allocated. The mutual learning of the UK Government (DCMS) who responded to commercial supplier feedback on creating more flexibility within the procurement contracts resulted in the DPS at the local authority-level (Section 5.6.3). The mutual learning and feedback loop the PCC Team has created with DCMS and the Welsh Government could procure additional investment due to the evidence of their stated 70% take-up rate (Section 5.4.2). Further SFC potential interventions will be explained in (Chapter Seven). Nonetheless, it is the assertion of this researcher that there is enough financial capital available within the ecosystem to resolve the final 95k. How these opportunities and challenges will be addressed depends upon the proactive HC productivity, SC collective action and IM analysis within both ecosystems.

6.9 HVS ecosystem – New innovative approach (RQ3)

A primary finding of this thesis is the use of the HVS as an ecosystem to connect the core assets of several stakeholders. One final assessment therefore is the use of the HVS as a novel approach to complex ecosystem-network analysis to answer RQ3. A summarised picture of the HVS connecting the core financial and non-financial capital assets of exogenous supply and endogenous demand stakeholders to answer RQ1 is presented in (Figure 6.26).

Figure 6.26 Hybrid Value System (HVS) – connecting stakeholder assets



In summary, there are multiple mutual learning & cooperative interplay opportunities to answer RQ2. In addition to the First in Wales initiatives is the value of the HVS as a new and innovative approach to complex ecosystem engagement to answer RQ3. Potential intervention areas will be presented in (Chapter Seven).

6.10 Credibility, reflection, reliability & validity - Results

A case study protocol (Appendix G) and case study checklist (Appendix H) were followed to ensure credibility, reliability and trustworthiness (Section 4.12). Detailed thematic analysis (TA) checklists, process for coding and codebooks are found in (Appendix J & K). For a summary of academic robustness and trustworthiness, the following processes were applied:

1. **Organisation using NVivo** – due to COVID19 outbreak during the data analysis the University was closed during lock-down. As a result, NVivo was used for audit trail and data analysis to include analytical memos, annotations, cross-referencing and research journals to capture coding decisions (Section 4.12). More specifically, a coding framework captured the nuances of the operational definitions to clarify thematic analysis (TA) and thematic network analysis (TNA) which was critical to the refined data analysis throughout Chapter's Five & Six (Section 4.11.1 - 3, Appendix J & K). The use of A3 paper maps to supplement NVivo online work for code diagramming and mapping resulted in (n=36) for data analysis. Overall detailed data analysis and step-by-step process displaying complex A3 coding maps are shown in (Appendix J.3).

Please note, due to COVID19 and closure of the University, printing interview transcripts and analytical memos was not possible. This made analysis work more challenging, although supplemented by A3 paper maps. Ideally, printed copies of all electronic transcripts, on-line coding and analytical memos would have been preferrable.

2. **Credibility** (Respondent Validity) (Section 4.12):

i. Observations (6-month Taskforce as sole researcher = 12.5 hours of meeting notes & engagement, Welsh Government Event = 5 hours, Conferences (n=3) = 15 hours).
ii. Supply interviews (n=14) with governmental experts & CEOs (Welsh Government, Local Authority, Openreach, Altnets).
iii. Demand interviews in 2016 (n=7) with Microbusiness owners in deep rural Wales.

iv. Demand interviews in 2020 (n=5): 2 x LDC IT experts with two decades of living in deep rural Wales hamlet (rich description), Ward Councillor, MB and former head of NFU Cymru with decades of local authority, business and farming experience in Pembrokeshire.

v. Secondary document analysis included government meeting agendas, PowerPoint presentations, government reports, PCC Survey findings, YouTube analysis for technical understanding on reaching the final few (Section 5.2.5, 5.10 & Appendix L).

Overall TOTAL = 26 expert interviews and 32.5 hours of first-hand observation data with governmental and commercial experts in this field.

3. **Credibility** (Triangulation) (Section 4.12) – the observation, interview and document analysis data are interwoven amongst the nation-level (macro) contextual findings (Chapter Five) and the local-level (micro) analysis (Chapter Six) and have been identified as such. References to supplementary reports, particularly those for MB statistics and demand analysis have been cited as and where relevant. For example, the PCC Survey (150 participants) asked questions about Internet use and so forth which did not require duplication. Hence, the Digital Pembrokeshire Twitter (& Facebook) findings are sufficient to refer to as the demand was evident within the county (Digital Pembs, 2019b). For example, "what do you use the Internet for?" (e.g. 78% surfing/shopping while 13% videoconferencing). "Are you happy with how your Internet speed works for you"? (e.g. 75% replied unhappy) (see Appendix L for infographic). Thus, duplication of these survey questions, in correlation with previous rural broadband studies (Section 3.5) were deemed redundant.

4. **Prolonged engagement** (Appendix J.2) – this study began in 2016. Engagement with Mr. G (LDC SV) has developed over four years and 10 hours of interviews. Interviews with supply experts were 45-90 minutes. Interviews with demand experts were 60 minutes – 4.5 hours. Six-month engagement on the Welsh Government Rural Digital Taskforce as the sole researcher. Manual editing of all interview transcripts and writing up of all handwritten notes from conferences, events and Taskforce meetings.

5. **Member checks** (Section 4.12) – all semi-structured instruments were pilot tested with experts (Section 4.10). Member checks were particularly useful for technical assurances with LDC (INT1) and Openreach (INT3). Clarification and verification during the interviews (e.g. State Aid contractual issues, Section 5.4.1.3.2) were included. In addition, transcripts were sent to participants who asked for a copy and any further verification or corrections were included (INT7, 12, 17 & 18).

6. **Transferability** (Rich Description) (Section 4.12) - thick description of case study and hard-to-reach deep rural context was used to describe Splits-Ville and the two decades of problems the LDCs (as IT experts & residents) had experienced to access reliable rural broadband and mobile services (Section 4.7.1 & 5.8).

7. **Dependability** (Complete & Detailed Records Throughout all Phases of Research) (Section 4.12) - description of audit trail are detailed in the data collection Procedures I-VI (Section 4.8), case study protocols (Section 4.7, Appendix G & H), thematic data analysis checklists for trustworthiness (Appendix J.2) and overall detailed data analysis procedure (Appendix J.3).

In addition, three x 150-page notebooks were used by the researcher to reflect on academic learning throughout this process using the analytical memo process and methodology described in (Section 4.11.4) and field procedures (Section 4.7.2) as well as a 40-page NVivo research journal to reflect on coding process. Chapter Five has (n = 31) quotation maps. Chapter Six has (n = 26) quotation maps to ensure thorough analysis and presentation of the findings.

8. **Confirmability** (Acted in Good Faith) (Section 4.12) - every effort was made to ensure transparency, reliability, reflection, trustworthiness and validity for this unique in-depth exploratory intrinsic case study as described in (Section 4.7) and checked against the case study protocol (Appendix G & H) and data analysis checklists (Appendix J.1, J.2, J.3 & K).

6.11 Conclusion – Local-level (micro) analysis (RQ1, 2 & 3)

Five cross-cutting themes were identified in the nation-level findings (Section 5.11, Table 5.8). These included the "First in Wales" proactive local authority-level initiatives in Wales, the value of HC, SC, SFC, and the complexities of the full fibre network build (Section 5.11). The evidence presented in both the nation-level (macro) context (Chapter Five) and the local-level (micro) analysis (Chapter Six) reveals a substantial valuable amount of HC, SC and SFC capital resources available within both complex ecosystems. The interweaving of positive HC productivity & SC collective action are CSFs to get the job done and reach the final 95k. The converse is equally true. If the HC & SC are lacking or negative within either ecosystem, it hinders HC productivity and undermines SC collective action to "get the job done".

Exogenous supply

In the supply ecosystem, the value of HC skills, knowledge & personal attributes contribute extensively to the productivity of supply ecosystem-networks (Section 6.3). The leadership (skill) defined by dynamic enthusiasm (personal attribute) is the driving force for a top-down approach (Section 6.3.2). The responsiveness of the delivery teams motivated by the leadership team, drives the "First in Wales" initiatives (Section 6.3.3). The proactive response by local authority leadership drives the local delivery teams. The EOs unique set of people skills (e.g. the ability to deal with people in a friendly & effective way that achieve good results) and soft skills (e.g. ability to communicate & work well together) creates trust within the rural demand ecosystem (Section 5.4.3, 6.4.2 & 6.6.2). The EOs local tacit knowledge identified the spectrum of human behaviour (e.g. altruistic versus "what's in it for me" attitudes) and local Champions as non-financial value-adds (Sections 6.3.4 & 6.3.6). Thus, the interweaving of both HC (skills, knowledge & positive personal attributes) and positive SC (trust, relationships & networks) approaches are required to reach the final few.

Endogenous demand

In the demand ecosystem, the value of the HC skills, knowledge & personal attributes within the endogenous demand ecosystem are embodied by the local digital champions (LDCs) (Section 6.5.2). The value of IT, people & soft skills accompanied by the

relationships developed, within both place-based (internal) and network-based (external) networks is another non-financial value-add for HC productivity & SC collective action (Section 6.5 & 6.6). The identification of altruism as a positive personal attribute is a new finding and another non-financial value-add within rural communities; both strategically as a non-financial resource for EOs and local authorities, but also as volunteer efforts within the community to "get the job done".

The merging of HC & SC skills amongst the IM mediators & knowledge brokers are vital contributions within both ecosystems (Section 6.4.8 & 6.6.2). The value of communication (e.g. the process of sharing information, especially when it increases understanding/knowledge between people & groups) is a non-financial value-add (Section 6.3.5). This finding will be explored further (Chapter Seven).

The value of the IM mediator role (e.g. conflict resolution) and the knowledge broker role (e.g. to freely disseminate understanding of & information about) are CSFs within both complex ecosystems (Section 6.4.8 & 6.6.2). Mediator roles can be defined as people within the network possessing conflict resolution skills (e.g. Mr. P), but also "hubs" (e.g. the joined-up approach for a single point of contact within the Taskforce & Local Authority) (Section 6.4.7). The knowledge broker "hubs" can be people (e.g. Mr. G) or Citizen Service Organisations (CSO) (e.g. INCA, RSA or UK5G conferences) alongside governmental hubs (e.g. PCC local authority or Taskforce). A centralised hub (IM) as a "single point of contact" to aid barrier busting disputes or to enquire about funding is a non-financial value-add to reduce blockages and frustrations within the networks (Section 6.8.1). Hence, IM mediator and knowledge broker "people & hubs" play a consequential role within complex ecosystem-networks.

The demand SC contributions for collective action are bolstered by trust, relationship behaviour, and networks for working together & sharing information (Section 6.4.2 & 6.6.2). The value of relationship behaviour such as Community Spirit (e.g. friendliness & understanding between local people) and the "essential tool in the tool kit" of relational ties with local authorities is a notable non-financial value-add for collective action (Section 6.6.3). The approaches to relationship behaviour to "engage not enrage" and the approaches to networks to facilitate working together & sharing information is exemplified by the joined-up, collaborative and partnership approach

(Section 6.4.5 & 6.6.4). Henceforth, the non-financial value-add of both HC & SC, within both ecosystems, is "data rich" and should not be squandered.

The research questions (RQs)

RQ1 asks what capital resources are required to support infrastructure for NGA to be viable for rural communities and microbusinesses (MBs) to experience four-fold capital benefits? The SFC resources are plentiful but need to be managed correctly in order to reach the final 95k. The value of HC & SC is endemic throughout both ecosystems to exemplify the HC productivity required for SC collective action (Section 6.2 & 6.7). Thus, the non-financial capital resources play a significant role, alongside infrastructure, to reach the final few.

RQ2 asks how can multiple stakeholders, in both complex ecosystems, mutually learn and cooperate to resolve the rural digital divide? The mutual learning & cooperative interplay are evidenced throughout both ecosystems (Section 6.8). The case study network innovation (or IM) analysis provides a snapshot of a "top-down" knowledge flow from the Taskforce "Object Connect" joined up approach and single point of contact to enable local authorities and EOs to address blockages more readily for barrier busting and conflict resolution (Section 6.8.1). In addition, the SFC mutual learning & cooperative interplays are evidenced throughout the supply ecosystem (Section 6.8.2). The allocation of clawback funds to benefit the final 95k, the HC required to develop a Digital Infrastructure Investment fund (DIIF), the flexibility of timebound contracts, the 70% take-up rates to stimulate investment and the "Wall of Money" partnership opportunities are limited only by robust business models and creative partnerships (Section 6.8.2). Thus, SFC mutual learning & cooperative interplay opportunities and challenges are awaiting proactive HC & SC leadership and are hindered by the lack of HC & SC abilities. Open innovation, co-creation and multi-stakeholder engagement IM opportunities abound within the SFC ecosystem and will be discussed further in (Chapter Seven).

Finally, RQ3 asks what new and innovative approaches can be used to manage and measure this process. The "First in Wales" initiatives exemplify the value of positive HC & SC to answer RQ3 (Section 5.11). However, they can only be measured once the "glass is in the ground". Apart from the "First in Wales" initiatives, is the mutual

business approach, identified in the literature, to utilise the HVS to assess the HC, SC, EC and SFC embedded within both ecosystems (Section 3.8.7 & 3.8.8). The mutual business NED/HVS approach has proven to be a valuable assessment tool for identifying and analysing capital resources within complex ecosystems (Section 6.9). These findings will be discussed further in (Chapter Seven).

In conclusion, the four-fold capital resources are assets (inputs) as well as benefits (outputs) within the complex ecosystems (RQ1). The mutual learning & cooperative interplay amongst multiple stakeholders can create new and exciting opportunities to reach the final few (RQ2 & 3). The only challenge hindering these initiatives is the lack of proactive HC productivity & SC collective action to get the job done and reach the final 95k. The demand for full fibre connectivity post-COVID19 outbreak is evidenced. Connectivity during COVID19 affected the environment (EC), social inclusivity (SC) and working from home capabilities (HC). Henceforth, the resolution of rural NGA supply and demand has become more urgent. The relevance of these findings, including potential intervention areas, and new knowledge contributions amongst the previous literature which will be discussed in the following (Chapter Seven).

Chapter Seven: Discussion

7.1 Introduction & Chapter Overview

This chapter discusses the positioning of this research amongst the literature (Section 3.5 – 3.7) and the applications and value of this study within the conceptual framework (Section 3.8.8) to answer the research questions (RQs). The nation-level (macro) findings (Section 5.2) drove the changes to the instrument design and subsequent re-focus of the original plan for this research (e.g. NGA demand assessment moved to Appendix N for future research). As explained in (Section 4.10) the neo-endogenous (NED) conceptual framework was re-worked to accommodate the divergence from a "bottom-up" or mutual-approach to a "top-down" local authority-level approach (e.g. introduction of the Engagement Officers (EOs) to case study area). Nevertheless, there are significant findings within both the supply (network-based) and demand (place-based) ecosystems to be discussed in this chapter.

This chapter summarises the complexities of this research (Section 7.2). A summarised findings map to capture the complexity is explained in (Section 7.2.1, Figure 7.1). The regional context is reviewed (Section 7.2.2). A summary of expected and unexpected findings of this research and the positioning amongst previous literature is discussed in (Section 7.3). The application and value of this research is summarised with four potential intervention areas and examined in relation to the literature and conceptual framework (Section 7.4).

The first potential intervention area (P1) discusses Splits-Ville B (SV-B) and how the human, social and financial capital was lost and squandered versus appreciated and valued to reach final few (Section 7.4.1). A detailed discussion relating P1 to previous literature core concepts is summarised in (Section 7.4.1.2). The second potential intervention area (P2) discusses Splits-Ville A (SV-A) and the net-value of human & social capital inter-relationships to reach the final few (Section 7.4.2). A detailed discussion relating P2 to previous literature core concepts is summarised in (Section 7.4.2.4). The third potential intervention area (P3) discusses the nation-level mapped analysis and how innovation (IM) opportunities can be actioned to reach final few (Section 7.4.3). A detailed discussion of how (P3) IM analysis related to previous literature core concepts is summarised in (Section 7.4.3.1). The fourth potential

intervention area (P4) discusses the local-level mapped analysis and how innovation (IM) opportunities can be actioned to reach the final few (Section 7.4.4). A detailed discussion of how (P4) IM analysis related to previous literature core concepts is summarised in (Section 7.4.4.1). A reflective researcher mapped network visualization tool is presented in (Section 7.4.5).

Finally, the new findings and revised conceptual NED framework to answer the RQs is presented in (Section 7.5). The fulfilled gaps in the literature are discussed in (Section 7.6) and conclusions are summarised in (Section 7.7).

7.2 Discussion & findings

The network of interlinked core concepts from the literature review (Section 3.8) made this research complex by involving multiple stakeholders across two ecosystems and identifying the four-fold capitals as assets/resources and benefits. The interweaving of the core concepts from the rural academic field combining mixed neo-endogenous (NED), resilience and place-based theories (Section 3.8.1), plus the rural broadband critical success factors (CSFs), Altnet opportunities and rural partnerships (Section 3.8.2). All of these concepts, coupled with the drivers, opportunities, barriers and failure factors for both the exogenous supply and endogenous demand (Section 3.8.3 & 3.8.4) made the outcomes of this research multifaceted (summary Sections 5.11, 6.7, 6.8 & 6.9).

The innovation (IM) analysis of ICT creative destruction opportunities within Industry 4.0, and the 21st-century thinking required for ecosystems, networks, mediators, knowledge brokers, open innovation, co-creation and multi-stakeholder engagement provided a new context to “think outside the box” (Section 3.8.5).

The CSFs of human & social capital identified across all of the domains (e.g. academic field, rural broadband & IM literature) provided the theoretical underpinning for this research (Section 3.8.6). In addition, the four-fold capitals identified as an outcome and benefit of advanced broadband in rural communities (Section 2.2.5) and as rural assets to be invested or squandered (Section 2.2.3 & 3.5.1) provided both input and output analysis within the NED/HVS conceptual framework (Section 3.8.7). Despite the volume and complexity of the data (Section 5.1.2), the Hybrid Value

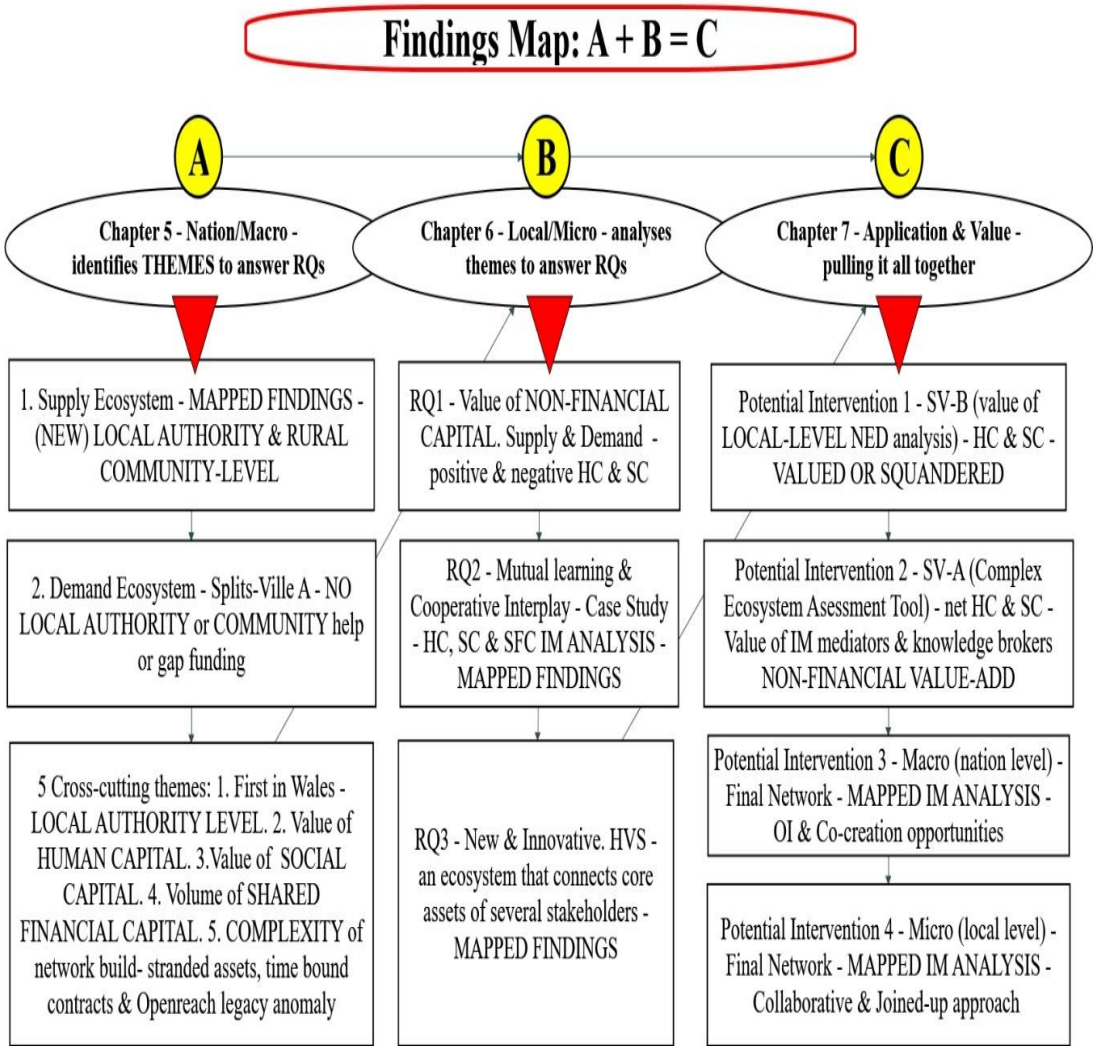
System (HVS) held the complexity, the multiplicity of stakeholders, and the literature concepts together for analysis (Section 3.8.8).

The HVS therefore was a useful tool and approach that extracted rich data from multiple stakeholders in both ecosystems (Chapter Five). The complexity of data analysis provided multiple findings to answer the RQs (Chapter Five & Six). Thus, one primary outcome of this thesis is **how to manage complexity** using NED (e.g. both supply & demand ecosystems) with the HVS approach (e.g. an ecosystem connecting core assets of multiple stakeholders) at the **local-level** to get the job done and reach the final 95k. More specifically, the NED/HVS conceptual framework captured the core concepts identified in the literature, thus fulfilling numerous research gaps and adding new knowledge to the academic field, rural broadband & IM literature (discussed below in Section 7.6).

7.2.1 Finding summary map (A + B = C)

To summarise the complexity and multiplicity of findings the following diagram illustrates how Chapter Five (A) five cross-cutting themes were captured in Chapter Six (B) for more detailed analysis to answer the RQs and summarised in Chapter Seven (C) through four potential intervention areas (Figure 7.1).

Figure 7.1 Finding Summary Map – A + B = C



** Key findings & salient points are CAPITALISED. Chapter 5 (A) findings flow sequentially from top to bottom, then transfers to Chapter 6 (B) detailed analysis to answer RQs 1, 2 & 3. A + B findings culminate into four potential intervention areas to discuss the application & value of this research in (C) Chapter7.*

(A) Chapter Five (macro-nation-level) - identified the **new** "First in Wales" initiatives that focus on the **local authority** and rural community level. The **five cross-cutting themes** captured this new level of engagement and extended new findings within human capital, social capital and shared financial capital (e.g. Wall of Money) (Section 5.11). The complexity of the network build was another surprise by identifying stranded assets, timebound contract constraints, the Openreach anomaly and labour (HC) shortages that provided additional and previously undisclosed barriers in prior research. These findings will be discussed further in (Section 7.3 & 7.4).

(B) Chapter Six (micro-local-level) - detailed the findings from Chapter Five to answer the RQs. To reiterate the RQs:

1. RQ1 asked what capital resources are required to support infrastructure for NGA to be viable for rural communities and MBs to experience four-fold capital benefits?

   A detailed examination of the operational **definitions** provided a deeper or more nuanced, or granular level analysis, to the non-financial value-add of human & social capital (Sections 6.3 - 6.7). These new findings will be discussed further in (Section 7.3 & 7.4).
2. RQ2 asked how can multiple stakeholders in both supply & demand ecosystems mutually learn & cooperate to resolve this complex digital divide challenge?

   The **mapped findings** to illustrate the mutual learning & cooperative interplay from a joined-up, top-down case study network analysis was presented (Section 6.8.1, Figure 6.23). This figure (6.23) encapsulates the multi-faceted findings from IM analysis of knowledge flow, centralised hubs for barrier busting, conflict resolution and communication. The illustration captures the new findings of the value HC people skills (e.g. friendly & effective) and soft skills (e.g. face-to-face communication that builds trust). The new finding of Welsh Community Spirit as an SC asset to engage (e.g. friendliness & understanding between local people) and value. Friendly is defined as behaving in a pleasant, kind way towards someone. Moreover, the mapped illustration of numerous new shared financial capital (SFC) mutual learning & cooperative interplay opportunities are captured in (Section 6.8.2, Figure 6.25). These new findings and applications will be discussed below (Section 7.3 & 7.4).
3. RQ3 asked what new and innovative approaches can be utilised to manage and measure this process?

   As discussed in the Chapter Six conclusions (Section 6.11), aside from the "First in Wales" local authority initiatives, are the mapped findings from the **NED/HVS conceptual framework** approach which extracted rich financial and non-financial capital data, both positive and negative, from both supply & demand ecosystems (Section 6.9, Figure 6.26) for analysis. These new findings and applications will be discussed below (Section 7.3 & 7.4).

(C) Chapter Seven (application & value) – this chapter will correlate the findings in relation to the literature review core concepts (Section 3.8.1 – 3.8.7) and discuss the new findings through four potential intervention areas (Section 7.4). The **HC-SC intervention discussions** focus on Splits-Ville B (SV-B) and Splits-Ville A (SV-A) (Section 7.4.1 & 7.4.2). The **innovation analysis (IM) interventions** at the macro nation-level and micro-local level will be discussed in (Sections 7.4.3 & 7.4.4). Evidence that confirms, extends or adds new knowledge will be discussed below in (Sections 7.3 - 7.5).

7.2.2 Context of this research

Industry 4.0 is the UK Government's ambition to provide "full fibre & 5G" technologies to realise the use of technological advances for economic benefit (Section 1.4). However, only two participants (INT12 & INT15) were aware of "Industry 4.0" terminology (Section 5.9). Terminology such as "Digital Revolution" or "Internet of Things" was more recognisable, and Agri-tech is becoming an exciting prospect in rural Wales (Section 5.9).

The regional context of Pembrokeshire was selected because it is one of the three regions in Wales with remote rural "white premises" and challenges to reach the final 95k (Section 2.3.3). The Splits-Ville (SV) case study area within Pembrokeshire is typical of the final few and hard to reach areas in Wales (e.g. Splits-Ville B is in a valley with trees & no line of sight for fixed wireless solutions; the cost of upgrading the existing infrastructure was too much for the community to assume) (Section 5.8.1). SV-B is currently managing with satellite connectivity and 4G mobile as and when they are able to connect with a signal (Section 5.8.2).

The introduction of the Engagement Officers (EOs) into the case study area changed the focus for this research, in that it gave an opportunity to observe the initiative of a "top-down" pilot scheme to connect the area with full fibre (Section 5.4.3). If the pilot scheme wanes for any reason (e.g. failed negotiations, labour shortages, protracted delays or time constraints) then rural communities may have to resort again to "bottom-up" community-led or DIY initiatives.

7.3 Positioning this research amongst the literature

The conceptual framework was created from the core concepts and gaps in both the rural broadband (BB) and innovation (IM) literature (Section 3.8). To position this research amongst the literature, this section discusses what findings were expected (Section 7.3.1) and unexpected (Section 7.3.2).

7.3.1 Expected findings

The expected findings confirmed the summarised core concepts and gaps identified in the literature (Section 3.8.1 – 3.8.7). Details of extended and new knowledge will be discussed in the unexpected findings (Section 7.3.2), the four potential intervention areas (Section 7.4) and the revised conceptual framework (Section 7.5). The following summarises the expected findings within each core concept.

7.3.1.1 Core concept - Academic field – Complimentary theories

The rural academic field identified complimentary theories (Section 3.8.1) that have been incorporated into this research. The neo-endogenous (NED) economic growth theories by combining place-based (local milieu) theory with internal & external networks (Section 3.2.4). This study confirmed and extended NED theory in rural BB literature (Section 3.5.1.1) by providing evidence that both internal & external networks are required at the **local-level** to work together to resolve NGA access (Section 6.8.1 & 6.8.2).

Moreover, this study extended rural broadband NED theory by applying the HVS mutual business (IM) approach to connect core assets of several stakeholders (Section 6.9). Resilience theory identified human agency, capitals and place-based (local milieu) as CSFs to stop out-migration and develop resilience for rural communities and MBs (Section 3.5.1.2 & 3.5.3.2). This research confirms, extends and adds new knowledge to the cross and multi-disciplinary rural academic field and will be discussed further in (Section 7.4).

7.3.1.2 Core concept - Rural broadband (BB) literature

The rural BB literature identified critical success (CSFs) and failure factors within rural communities which were confirmed and extended in this study (Section 3.8.2). This research confirms the CSFs of LDCs, human capital (leadership & IT skills), social capital (bonding & bridging networks) and trust are required (Section 6.3 – 6.6).

Nevertheless, this research extends the CSFs with additional layers of HC-SC analysis (e.g. value of altruism, people & soft skills and Welsh Community Spirit). The extended and new evidence will be discussed in unexpected findings (Section 7.3.2) and potential intervention areas (Section 7.4.1 & 7.4.2).

7.3.1.3 Exogenous supply stakeholder ecosystem

This research confirmed the previously identified supply-side drivers, opportunities, barriers & failure factors (Section 3.8.3). The drivers of Industry 4.0, the entrepreneurial creative destruction opportunities and quality of life assertions were confirmed (Section 5.8.3, 5.8.5.1 & 5.9). The supply drivers & opportunities of barrier busting taskforce, improved state aid, new business models and local government required to allocate funding were additionally confirmed (Section 5.2). The supply barriers of cost, geography, reliable backhaul and return on investment remain evident. More specifically, the failure factors of compressed timelines, bureaucracy and misallocation of funds were corroborated in this thesis (Section 5.5, 5.8 & 5.10.2). Nevertheless, new supply-side drivers, opportunities, barriers and failure factors have been identified. Moreover, new supply CSFs have been identified which were not previously acknowledged in rural BB literature. These new findings will be discussed in the revised conceptual framework (Section 7.5).

7.3.1.4 Endogenous demand stakeholder ecosystem

The previously identified demand-side drivers, opportunities, barriers, CSFs & failure factors have been confirmed in this research (Section 3.8.4). Demand drivers for Industry 4.0 such as teleworking, education, quality of life, removing geography limits, enabling and supporting economic transactions have been confirmed and extended in this research (Section 5.8.3, 5.8.5 & 5.9). The demand opportunities such as the clawback clause has been confirmed and extended (Section 6.8.2). The demand barriers and failure factors of distrust, government failings, lack of skills and the need for local government to allocate funding have equally been confirmed and extended (Section 5.8.2). Nevertheless, new demand-side drivers, opportunities, barriers, failure factors and CSFs have been identified and will be discussed in revised conceptual framework (Section 7.5).

7.3.1.5 Core concept - Innovation management (IM) analysis

The IM analysis discusses 21st-century thinking and how information and knowledge flows, success and failure factors, appropriability conundrum of who profits from innovation and the fifth generation of "system integration & networking" to engage supply & demand (Section 3.8.5). Moreover, IM discusses the value of entrepreneurial creative destruction opportunities, dynamic versus static ecosystems, product champions, knowledge brokers, new business models, open innovation (OI), co-creation & multi-stakeholder engagement (Section 3.7). These concepts are confirmed and extended in this thesis (Section 5.8.2, 5.8.3 & 6.8.1). Hosseini et al. (2018) were some of the first to incorporate open innovation (OI) thinking into the rural BB literature. This research adds new IM knowledge to rural BB literature and will be discussed further in (Section 7.3 & 7.4).

7.3.1.6 Core concept - Human & social capital (CSFs)

Human capital is tied to community-led development, economic growth and IM creative destruction entrepreneurial opportunities (Section 3.8.6). Social capital can have positive or negative impacts and high or low trust quotients are related to investment-fertility. HC & SC, similar to financial capital, can be valued and invested or lost and squandered (Section 3.6.5 & 3.6.6). This thesis has confirmed these assertions and extended the theory by adding new levels of HC & SC knowledge to rural BB and IM literature. New findings will be discussed in unexpected findings (Section 7.3.2) and the four potential intervention areas (Section 7.4).

7.3.1.7 Core concept - Four-fold capitals – Inputs & outputs

The four-fold capitals identified as inputs (assets) & outputs (benefits) (Section 3.8.7) has been confirmed and extended in this research (Section 5.8.3 & 6.9). Details on how this research has extended and added new knowledge will be discussed further in the four potential interventions (Section 7.4) and revised conceptual framework (Section 7.5).

7.3.2 Unexpected findings – Five cross-cutting themes & definition detail

There were multiple "surprises" during this research. To provide a summary of unexpected findings, the following section will detail the macro-nation (Chapter Five) and the micro-local level findings (Chapter Six). Further discussion of unexpected findings will be highlighted in the four potential intervention areas (Section 7.4) and

revised conceptual framework (Section 7.5). The five-cross cutting themes identified in Chapter Five (Section 5.11), are themselves a summary of unexpected findings, but will provide the framework for discussion.

7.3.2.1 Local authority-level – Firsts in Wales

The numerous "First in Wales" initiatives at the **local authority-level** was a surprise. Notwithstanding the newly formed Welsh Government Rural Broadband Taskforce to engage with local-authorities, but the proactive and ambitious approach of the Pembrokeshire County Council (PCC) and subsequent EO pilot scheme to combine supply and demand and target the final few. Previous rural broadband studies identified the requirement to engage supply and demand at the local community level (Ashmore et al., 2016; Hallstrom et al., 2017; Halseth et al., 2019; Salemink et al., 2017 in Section 3.5.1) but seemingly few governments and local authorities had achieved this.

Another unexpected finding was the **PCC stated 70% take-up rate** because there was some confusion over the low take-up rates of UFBB in both EU literature (Briglauer & Gugler, 2019; Abrardi & Cambini, 2019 in Section 3.5.4) and from AM Lee Waters statement in (Section 1.5). Nonetheless, this is a surprising and welcome statistic for investment.

Another unexpected finding was the new efforts to **hire local engagement officers (EOs)** for both PCC local authority and Openreach Community Fibre Partnership (CFP) (Section 5.4.3 & 5.6.1) with explicit HC people & soft skills.

7.3.2.2 Value of human capital (HC) – Non-financial value-add

There were multiple surprises which emerged from the interviews, such as the identification of positive and counterproductive HC. The **proactive approach** exhibited by the Taskforce, PCC and certain local authorities was a positive surprise to reach the final few (Section 6.3.3).

The value of HC **people & soft skills** was an unexpected finding (Section 6.3.5). People skills deal in a friendly and effective way to achieve good results. Soft skills is ability to communicate and work well together. These "under-valued" skills, as compared to tangible "hard skills" such as IT, were not previously discussed in the rural BB literature.

Another significant unexpected finding was the EO's **HC local tacit knowledge** and the identification and value of the "**spectrum of human behaviour"** (Section 6.3.6). This could be identified as an HC skill, knowledge or SC behaviour for relationships. For example, it could be an HC people & soft skill to identify altruistic volunteers, as well as local tacit knowledge which comes from years of experience when dealing face-to-face (F2F) with people. Nonetheless, it was named by the EO as "behaviour" and behaviour in this research context is attributed to SC. Regardless, the identification of altruism versus what's in it for me attitude/behaviour is a new finding amongst the rural BB literature. Future research could further investigate the polar-opposite motivations behind this spectrum of human behaviour.

Finally, the discovery of the non-financial value-add of HC **personal attributes** such as **altruism** (e.g. wish to help or bring advantages to others, even if it results in disadvantage for yourself) (Section 6.5.3). In addition, the counterproductive (negative) personal attributes included envy, naysayers, passivity and scepticism (Section 6.3.7).

7.3.2.3 Value of social capital (SC) – Non-financial capital value-add

There were multiple surprises during the interviews such as an **extended definition of trust** from the supply ecosystem (Section 6.4.2). Trust was previously defined as reciprocity (Section 3.6.6) and organisational trust as ability to get things done (Section 3.6.6.1), but the respondents added subjective meaning to the definition by stating confidence, mutual respect, transparency and the right environment to challenge ideas.

Another unexpected finding was the **approaches** (e.g. a way of doing something; an act of communicating with another person or group in order to ask for something) to SC relationship behaviour and networks (Section 6.4.4 & 6.4.6). To **"engage not enrage"** was a surprising statement but encourages positive relationship behaviour when working with various stakeholders across both networks (Section 6.4.4). The **value of relationship behaviour** and the friendliness and understanding of the **Welsh Community Spirit** (Section 6.4.5 & 6.6.3) was an unexpected finding for both ecosystems.

The identification and **value of IM mediators, knowledge brokers and centralised hubs** (Section 6.4.8 & 6.4.9) coupled with the newly identified HC-SC

interplay was unexpected (Section 6.8.1). All of these are extended and new findings across the academic field, rural BB and IM literature.

New barriers to the conceptual framework were identified (e.g. counterproductive social capital) and will be discussed in the revised conceptual framework (Section 7.5).

7.3.2.4 Shared financial capital (SFC) – Wall of Money

There were multiple new financial opportunities discovered during this research (Section 5.2 & 5.6.5). Nevertheless, it was the amount of additional funding at the **local authority-level** that was unexpected given the problem area identified in this research as the cost and lack of financial resources to reach the final few (Section 1.5). It is this researcher's assertion there is a vast amount of funding available, but **"how" it is allocated** is the question (Section 6.8.2). These new findings will be discussed in SV-B potential intervention (Section 7.4.1), nation (macro) level and local (micro) level findings (Section 7.4.3 & 7.4.4).

7.3.2.5 Complexities of full-fibre network build

The complexities of the network build was a surprise. **Stranded assets** had not been identified or discussed in previous rural BB studies (Section 3.5.1 & 3.5.2). Time-bound constraints had been identified by Jackson & Gordon (2011) but were viewed as a rural-community funding application constraint and not a supply-contract challenge (Section 3.6.2.1). Furthermore, the **Openreach legacy anomaly** had not been identified or discussed in the rural BB literature and is a newly identified barrier/hindrance to FTTH access in rural communities (Section 5.8.6).

On the demand-side it was a surprise to discover Mr. G had **no recourse to present a business case to the local authority** to secure gap funding for Splits-Ville A or B (Section 5.8.2.3). The failure of the local authority to allocate funding was identified by Gerli & Whalley (2018). Nevertheless, this finding is confirmed and will be extended in the SV-B potential intervention area (Section 7.4.1).

In sum, there were multiple unexpected surprises during this research that were captured in the five-cross cutting themes (Chapter Five) and detailed definition analysis (Chapter Six). Nonetheless, further discussion through the four potential interventions areas (Section 7.4) and revised conceptual framework (Section 7.5) will complete the evidential discussion of this research.

7.4 Application & value of this research

This research investigated how a local-level and rural community approach may help to resolve the persisting digital divide supply and demand challenges in Wales (Section 1.1). Apart from the Pembrokeshire County Council Engagement Officer (PCC EO) pilot project (Section 5.4.2), additional approaches were identified as four potential intervention areas that can provide meaningful applications to help reach the final few (Sections 7.4.1 – 7.4.4).

The first potential intervention is a local NED analysis and how HC, SC and SFC can be valued or squandered within Splits-Ville B (SV-B) case study area (Section 7.4.1). The second intervention introduces the "Complex Ecosystem Assessment Tool" (CEAT) to illustrate and analyse the net HC-SC interplay within Splits-Ville A (SV-A) to "get the job done" (Section 7.4.2). The third and fourth potential intervention areas are an innovation (IM) analysis to discuss the open innovation (OI), co-creation and multi-stakeholder opportunities and challenges within the nation (Section 7.4.3) and local-level context (Section 7.4.4). Finally, the value of mapping ecosystem-networks as a visualisation tool for analysis is discussed (Section 7.4.5).

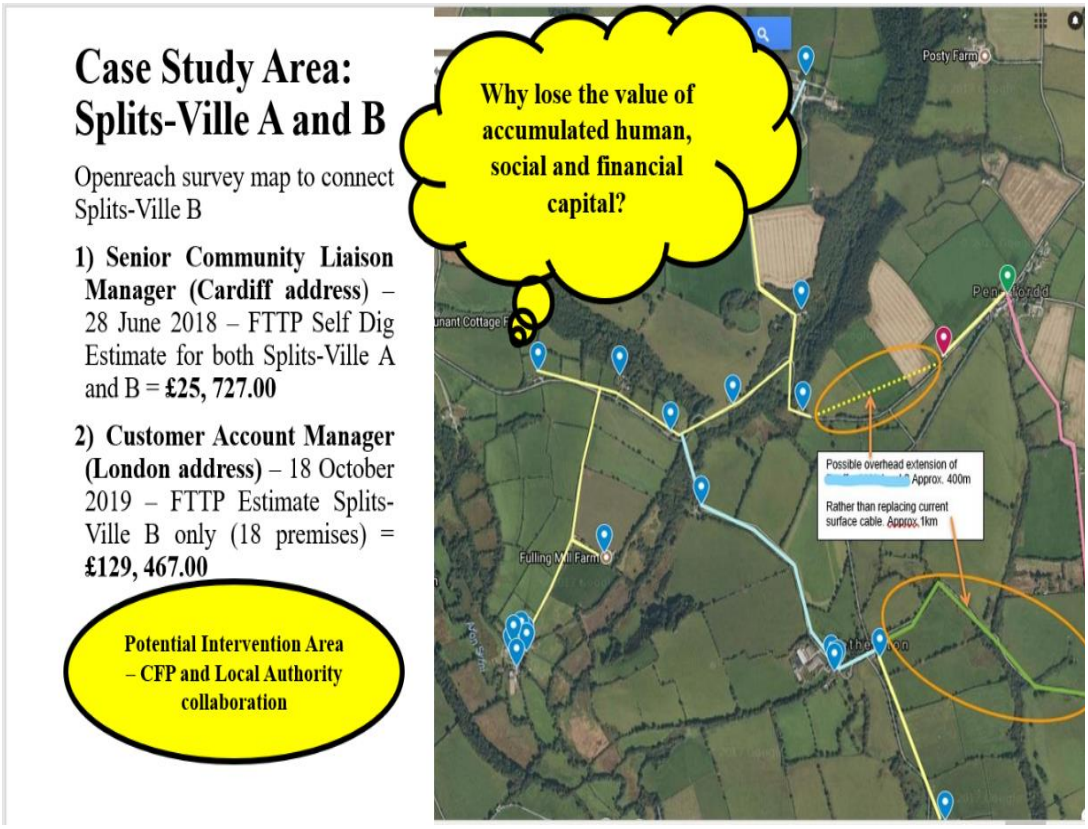
7.4.1 Splits-Ville B (SV-B) – Potential intervention (1)

During the demand interviews INT8 (LDC, SV-B) shared two different quotations provided by Openreach to enable FTTP for both SV-A and B. The FTTP quotations were provided after SV-A received SFBB (FTTC) in December 2017. The first Openreach FTTP estimate for both SV-A and B for self-dig (June 2018) and a second quotation 18-months later for FTTP for SV-B only (October 2019). The quotation disparity is over £100,000 more to do SV-B (a smaller job) in the same location (Figure 7.2). The problem, as explained to this researcher by the LDC (Mr. G), is that the original Openreach team they were dealing with had left the company. When they tried to revive the FTTP quotation for SV-B, another Corporate Account Manager (London, England address) was assigned, therefore losing all of the accumulated human, social and financial capital knowledge built up with the previous Senior Community Liaison Manager (Cardiff, Wales address).

7.4.1.1 "Capitalising" on human, social & shared financial capital

The loss of the accumulated human, social & shared financial capital is a potential intervention area. Instead of losing or squandering this valuable built-up capital, there is an opportunity for the local authority to engage with gap funding (Section 5.8.2.3). The original quote to connect both SV-A and B with a self-dig was four times less than the second quotation for SV-B only (Figure 7.2).

Figure 7.2 NED capital applications (local-level) - potential intervention (1)



**Quotations based on 20 properties per hamlet. Picture shows SV-B only.*

If Openreach and the rural community could partner with the local authority to provide this small amount of gap funding, it would have resolved NGA access to this final few hamlet for £25k or less. The rural community was willing to self-dig and both Mr. G and INT8 have a high level of human & social capital that both Openreach and the local authority could have capitalised on (Section 5.8.2, 5.8.5 & 5.8.6). The critical point is that by valuing the financial and non-financial capital and acting early to capitalise on these assets, in both supply & demand ecosystems, it could have prevented the inflated quotation.

In brief, SV-A and B could both have FTTH if there was a more collaborative or "joined-up" approach between the rural community (endogenous) and PCC local authority (exogenous), such as suggested in the rural BB (Section 3.5.1.2) and IM literature (Section 3.7.3). Mr. G had explained that prior to SV-A getting SFBB (FTTC), there was no utility within the local authority to discuss a business case to secure this kind of gap funding (Section 5.8.2.3). The PCC's EO approach will hopefully resolve this issue, but if it fails, for any reason, the rural communities will have to start again and re-invest their human, social, and financial capital with commercial suppliers and local government to resolve this issue (Section 5.8.5). Thus, reinforcing negative hindrances to supply and demand namely distrust, negative brand reputation and the squandering of time, money and effort (Section 6.6.5).

7.4.1.2 Discussion – Related to literature & conceptual framework

New drivers, opportunities, barriers, failure factors and CSFs for both supply & demand ecosystems core concepts (Sections 3.8.3 & 3.8.4) will be discussed in the revised conceptual framework (Section 7.5). This section will focus on discussing the benefits of local NED (rural BB) and HVS (IM) analysis (Section 3.8.1, 3.8.2 & 3.8.5) and the core concepts of human & social capital (Sections 3.8.6 & 3.8.7)

7.4.1.2.1 Academic field - NED analysis at local level (Section 3.8.1)

Previous rural BB NED studies (Bosworth & Salemink, 2014, June; Salemink & Strijker, 2016) identified the endogenous role of local actors (HC), the level of capital assets and resources available (SFC), network relationships (SC) and area or place specific (e.g. local milieu) (Section 3.5.1.1). Salemink & Strijker (2016) 8-stage model identified that market players would benefit from local HC expertise, SC and trust (Section 3.5.1.1, Table 3.9). However, it is evidenced that market players and local-authorities **do not value** or capitalise on local HC & SC.

7.4.1.2.2 Rural BB – CSFs & failure factors (Section 3.8.2)

Ashmore et al. (2015, 2017), Diaz-Andrade & Urquhart (2009), Halseth et al. (2019), Leong et al. (2016) and Wallace et al. (2015) identified LDCs, HC (IT skills), SC (bonding & bridging networks) and trust are required for successful community-led broadband (Section 3.5.1.2.1). This research confirms this assertion and adds new evidence that the **CSFs are not valued** by local governments or commercial suppliers.

Gerli & Whalley (2018) argued the failure factors of a top-down public-private partnership (PPP) approach because the local authority was ill-equipped to allocate funds to the hard-to-reach areas (Section 3.5.1.2.2). This study extends this evidence and finds the local authority was not only ill-equipped but did not provide the avenue to present a business case to secure a nominal amount of gap funding to reach the final few (Section 5.8.2.1).

a) <u>New evidence - Complexities & costs of network build</u>

This study provides new evidence regarding demand-barriers with administrative postcodes to telephone exchanges and associated costs by identifying the Openreach legacy anomaly (Section 5.8.6). New supply-barriers included stranded assets (Section 5.5.1). These new findings were only discovered by engaging with the hard-to-reach rural hamlet and by interviewing both supply & demand stakeholders at the **local-level**. Thus, contributing new knowledge by fulfilling the future research gaps identified by (Ashmore et al., 2015, 2017; Halseth et al., 2019; Salemink et al., 2017 in Section 3.5.1).

Rendon Schneir & Xiong (2016) analysis of the cost to rural BB being 80% higher by explaining the long distances, drop costs and so forth (Section 3.5.4). The document analysis on the complexities of network build (Section 5.10.2) confirm the challenges (Section 5.10.2.1) but show these costs can be greatly reduced by co-creation and user innovation with contractors and local communities (Section 5.10.2.5 & 5.10.2.6). Gerli & Whaley (2018) identified this massive reduction in FTTH build with B4RN (e.g. £10k per premise initial quote reduced to £700) (Section 3.5.1.2). This dramatic cost reduction is evidenced again here in SV-B. However, the **squandering of local HC & SC** by local authorities and commercial suppliers must be addressed if the final few are to be reached.

7.4.1.2.3 Human & social capital – Lost & squandered (Section 3.8.6)

Hallstrom et al. (2017) and RCUK-researchers such as Wallace et al. (2015) identify various rural capitals as assets and resources (Section 3.5.1). However, similar to financial capital, non-financial capital can be accumulated and invested or lost and squandered (Coleman, 1988; Lin, 2002; Putnam, 1993; Roche & Jakub, 2017; Schultz, 1961 in Sections 3.6.5 & 3.6.6).

This study provides evidence that the accumulated and valuable rural HC & SC was **lost and squandered**. Resulting in increased financial costs, failure of NGA access (FTTH) and the loss of four-fold capital benefits for SV-B.

b) <u>New evidence - Rural capital – cultivated or squandered</u>

Flora (2016) argued every community has assets and when invested in creating something new (e.g. SFBB) they become capital (Section 2.2.3). This intervention confirms that when HC & SC assets are invested, they can produce new infrastructure (e.g. built capital). Flora argues all capitals, as assets, can be cultivated or squandered according to each community's propensity to collaborate and act. In this instance, the place-based demand ecosystem (rural community) was willing to act, but the network-based supply ecosystem (local-authority) failed to collaborate. Hence, the distribution of resources (e.g. political capital) was squandered. This research focuses on the four-fold capitals, but Flora's seven-fold rural capitals can be identified within this context (Section 2.2.3).

7.4.1.2.4 IM Analysis – Not joined up (Section 3.8.5)

The identification and value of IM centralised hubs, mediators & knowledge brokers into rural BB NED analysis to reach the final few is a new finding (Section 6.8.1, Figure 6.23).

c) <u>New evidence - NED at local-level – not joined up (3.8.1)</u>

The value of combining rural broadband NED (Salemink, Strijker & Bosworth; 2014, 2016) and HVS (IM) analysis (Roche & Jakub, 2017) at the local level discovered the lack of a joined-up approach between the rural community and the local authority (Section 6.8.1). Ashmore et al. (2017) stated future research required a joined-up approach with participation on multiple levels (Section 3.5.1.2.3). This research provides the evidence and fulfils the gap. Moreover, the cross-disciplinary approach of this research contributes new knowledge to the academic field by implementing IM analysis to rural BB literature.

d) <u>New evidence - Local authority-level – no centralised hub</u>

The lack of a centralised hub to present a business case to secure nominal gap funding is a barrier for the final few. However, the benefits of a joined-up IM approach is illustrated in the case study area (Section 6.8.1, Figure 6.23) to overcome this obstacle.

e) <u>New evidence - Local authority-level – no SFC knowledge flow</u>

More specifically, this illustration highlights the lack of local-authority and rural community knowledge to capitalise on and acquire clawback clause, gap funding and other SFC opportunities identified in (Section 6.8.2, Figure 6.25).

f) <u>Evidence - Appropriability conundrum (IM)</u>

Another assertion is the ICT appropriability conundrum of who profits from innovation (Teece, 2006). This study provides evidence that if the local-authority and commercial supplier had valued the **non-financial capital value-add** of LDCs then all parties could have profited from the innovation (e.g. NGA access). The rural community would have profited with the proven four-fold capital benefits. The local-authority would have profited from the successful implementation of NGA at reduced costs and encouraging in-migration and reducing out-migration for rural development. The commercial suppliers would have profited from the non-financial collaboration to connect the final few market. Von Hippel (2005) argued not all profits are financial (Section 3.7.3). This study provides evidence that the non-financial motivations of the LDCs is profitable.

7.4.1.2.5 Four-fold capitals – Assets & resources (Section 3.8.6)

Schumpeter (1911) argued enabling entrepreneurial "creative destruction" opportunities creates economic growth (Section 3.7.1). This study evidences this assertion by confirming that SFBB has a positive entrepreneurial and four-fold capital effect on rural MBs (Section 5.7.1 & 5.8.3). This confirms and extends Lacohee & Phippen (2015), Pant & Odame (2017) and RCUK-research (Ashmore et al., 2015, 2017; Roberts et al., 2015, 2016; Townsend et al., 2015, 2017; Wallace et al., 2015; Williams et al., 2016) on how rural MBs can capitalise on the "creative destruction" opportunities provided by a fast and reliable BB connection (Section 2.4, 3.5.3.1 & 3.5.4). This evidence supports SFBB is required to encourage entrepreneurial MB in-migration (Section 5.8.5) and reduce out-migration which bolsters rural resilience (Ashmore, Phillip, Roberts, Townsend, Williams et al. in Section 3.5.3.1).

Moreover, this research provides new evidence by identifying and valuing four-fold capital assets (inputs) and benefits (outputs) **up front in the business model** by

trialling the HVS (Roche & Jakub, 2017) as a local NED assessment to reach the final few (Section 6.9). The following table synthesises the findings for potential intervention 1 (Table 7.1).

Table 7.1 Potential intervention (1) - related to literature/conceptual framework

Section	Core Concept/ Conceptual Framework	Literature/ Authors	Contributions
3.8.1	Academic field - NED, resilience & place-based (LM) theory	Terluin (2003) (Rural economic development requires mixed endo/exo & local milieu (LM) engagement). Salemink, Strijker, Bosworth (2014, 2016) (Rural BB NED requires local level analysis) Ashmore et al. (2015, 2017) (Resilience theory values human agency, rural capitals & place-based engagement).	**New evidence** This study fills the research gap & provides rural BB NED research at local level and introduces IM analysis to case study area (Section 6.8.1). Identifying how and why non-financial capital (HC & SC) is required alongside SFC for collaboration to reach final few. **New evidence** Adds cross & multi-disciplinary research to academic field.
3.8.2	Rural broadband	Ashmore (2015), Diaz-Andrade (2009), Halseth (2019), Leong (2016), Wallace et al. (2015) – CSFs - LDC, HC, SC & trust required.	**New evidence** CSFs are **not valued** by local authorities or commercial suppliers to reach final few. **New evidence** Had HC & SC been valued & capitalised on both SV-A & SV-B would have FTTH at significantly lower cost.
		Ashmore (2016) (Future research requires joined up approach) Gerli & Whalley (2018) (misallocation of funding at local-authority level)	**New evidence** IM analysis of case study area (Section 6.8.1, Figure 6.23) – requires centralised hubs & joined up approach to allocate funding. (Section 6.8.2, Figure 6.24).

3.8.5	Innovation analysis (IM)	Schumpeter (1911) (Creative destruction). Teece (2010) & Chesbrough (2010) (New business model innovation) Bessant (2015) (Ecosystems, networks, knowledge flows). Allen & Cohen (1969) (Gatekeepers & knowledge brokers) Tidd & Bessant (2009) (Centralised points & joined up approach) Teece (1986, 2006) & Von Hippel (2005) (Who profits from innovation)	**Extended evidence** SFBB enabled rural MBs to innovate new business models & grow four-fold benefits. **New evidence** The identification of IM ecosystem-networks, knowledge flows & knowledge brokers are required to reach the final few (Section 6.8.1). **New evidence** Appropriability conundrum could be resolved if all stakeholders valued non-financial capital for problem area resolution.
3.8.6	Human & social capital theory (CSFs)	Rural BB literature: Flora (2016) & Hallstrom et al. (2017) (Rural capital assets for investment). Lin (2002) (Investment of resources with expected returns in the marketplace). IM literature: Schultz (1961) & Becker (1994) (Value of HC – invested or squandered & lost). Coleman (1988), Putnam (1993), Roche & Jakub (2017) (Value of SC & trust – invested or squandered & lost).	**New evidence** Value of non-financial capital **HC & SC was squandered & lost.**

3.8.7	Four-fold capitals - inputs & outputs	IM literature: Roche & Jakub (2017) (Value four-fold capitals up front in business model).	**New evidence** Failure to value four-fold capitals as assets/resources (input) upfront – opportunity to resolve digital divide was squandered & lost. **New evidence:** SV-B lost four-fold capital benefits (output) with failed NGA access.
3.8.8	Conceptual NED/HVS framework	Rural BB literature: Salemink, Strijker, Bosworth (2014, 2016) (Rural NED analysis at local-level). IM literature: Roche & Jakub (2017) (HVS – connecting core assets of several stakeholders).	**New evidence** 21st-century new paradigmatic thinking required – to value non-financial capital alongside financial capital. (Section 6.9, Figure 6.26). **New evidence** By applying IM (HVS) analysis to rural BB (NED) literature – new opportunities to reach final few are identified.

** Critical Success Factors (CSFs), Hybrid Value System (HVS), Local Milieu or place-based theories (LM). Bold emphasis added to highlight new findings.*

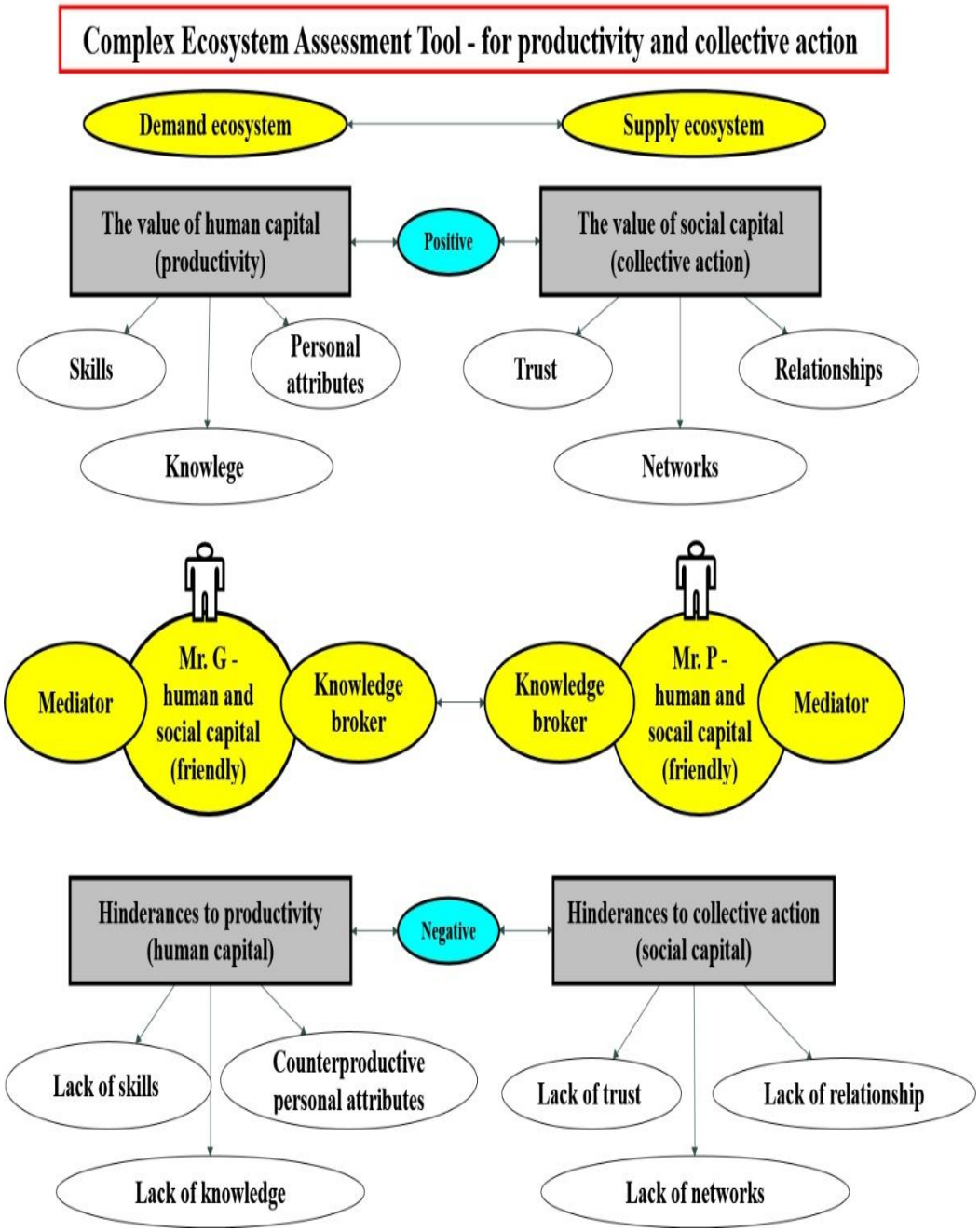
To conclude, the financial and non-financial capital can be accumulated and valued or lost and squandered by poor investment. In the case of SV-B, early interventions could have resolved FTTH for both communities at a reduced financial cost had the accumulated human & social capital been valued and capitalised on. Moreover, the failed attempt has a negative knock-on effect for SV-B because they are denied the four-fold capital benefits attributed to SV-A.

The value of IM analysis and OI, co-creation, and multi-stakeholder engagement by bringing together users (endogenous demand) and organisations (exogenous supply) should resolve local-level problems. One critical assertion is that the CSFs of LDCs and the value of HC & SC was not recognised by commercial suppliers or local government. Henceforth, it is suggested that exogenous supply (network-based) and endogenous demand (place-based) four-fold capitals can be brought together in the NED conceptual framework to connect the core assets of several stakeholders (HVS) and reach the final few (Section 6.9).

7.4.2 Splits-Ville A (SV-A) illustration – Potential intervention (2)

The value of human & social capital, both positive and negative, within the complex ecosystems is a core finding of this research, but how these inter-relate needs to be assessed. This finding is explained through an illustration of the HC productivity & SC collective actions of Mr. G (demand ecosystem) and Mr. P (supply ecosystem). The following diagram illustrates the concept of the complex ecosystem for discussion (Figure 7.3).

Figure 7.3 Complex Ecosystem Assessment Tool - potential intervention (2)



7.4.2.1 Complex ecosystems – Inter-relationships between supply & demand

The human & social capital inter-relationship between Mr. G (demand) and Mr. P (supply) created positive outcomes for SV-A (e.g. product to a final few market & validated SFBB four-fold capital benefit results for MBs) (Section 5.8.1 & 2.2.6). The synergistic value of their respective HC & SC resulted in successful productivity and collective action to "get the job done" and reach SV-A. However, not all ecosystems possess these types of individuals, hence the need to evaluate the level of positive or negative HC & SC within the complex ecosystem-networks. One outcome of this research is the identification of proactive productivity and counterproductive hindrance to human & social capital assets defined in (Section 6.3.7, 6.4.7, 6.5.5 & 6.6.5). **The inter-relationship between HC & SC is rarely dealt with in the literature** (Section 3.6.3 & 3.6.4) and this has led to the creation of a tool to assess these complex ecosystem relationships.

7.4.2.2 Utilising CEAT - To assess net value of HC-SC

The identification of productive (positive) opportunities and counterproductive (negative) hindrances to HC & SC within a prospective ecosystem can aid stakeholder decision-making to reach the final few. Hence, the "Complex Ecosystem Assessment Tool" (CEAT) can act as a visual aid for analysing the HC productivity & SC collective action opportunities and challenges therein.

For example, Mr. G and Mr. P represent a high value of human capital within their ecosystem-networks. Both stakeholders possess a high-level of desirable skills (e.g. communication, conflict resolution, IT, leadership, people & soft) (Section 6.3 & 6.6). Local and expert knowledge (e.g. both explicit & tacit) (Section 6.3.6 & 6.6.1). More significantly, it is the positive and productive personal attributes exhibited by both stakeholders (e.g. altruistic, friendly & proactive) (Section 6.3.3 & 6.5.3). Both parties equally possess a high value of social capital (e.g. trust from supply & demand stakeholders, positive relationships with supply & demand stakeholders, and the NED networks required to work together & share information to reach SV-A).

Furthermore, these two individuals represent both mediators & knowledge broker roles within their respective ecosystem-networks (Section 4.7.1). Mr. G acts as a mediator to resolve conflicts within the demand ecosystem, whilst acting as knowledge broker for the supply ecosystem (Section 6.5.2). Conversely, Mr. P acts as a mediator

to resolve conflicts within the supply ecosystem, whilst acting as a knowledge broker for the demand ecosystem (Section 6.4.5).

Moreover, the absence of the positive value of these two individual's human & social capital would make mutual learning and cooperative interplay for HC productivity & SC collective action more difficult (Section 6.8.1), similar to gatekeeper "Carol" in IM literature (Section 3.7.4.3). The hindrances to HC (e.g. lack of skills, lack of knowledge & counterproductive personal attributes) and the barriers to SC (e.g. lack of trust, lack of relationships & lack of networks) would make productivity and collective action more difficult to achieve (Sections 6.3.7, 6.4.7, 6.5.5 & 6.6.5). Thus, delaying the resolution of reaching the final few.

7.4.2.3 Complex Ecosystem Assessment Tool (CEAT) – Evaluation methods

The value of visualising both ecosystems as positive (productive) opportunities and negative (counterproductive) hindrances HC & SC interrelationships, as illustrated in (Figure 7.3), allows for multiple instances to be analysed within the complex ecosystem-networks. For example, governmental policy makers can use these illustrations to identify productive (drivers & opportunities) and counterproductive (barriers) within the supply and demand ecosystems. Local authorities can be illustrated to identify productive (drivers & opportunities) and counterproductive (barriers) within their constituency landscape. The CEAT can be used by academics, commercial suppliers and policy makers to identify productive (drivers & opportunities) and counterproductive (barriers) when working with rural communities, and to identify local digital champions (LDCs) from which to partner (Section 6.8.1). Therefore, the value of people (HC) and relationships (SC) within both complex ecosystems, is a critical success factor (CSF) for productivity and collective action to reach the final 95k. This is a net effect, whereby both positive/productive and negative/counterproductive hindrances to HC & SC need to be assessed.

7.4.2.4 Discussion – Related to literature & conceptual framework

This section focuses primarily on the HC, SC and IM analysis discussion. Nonetheless, contributions to the core concepts will be identified.

7.4.2.4.1 Academic field - NED local-level analysis (Section 3.8.1)

This research confirms and extends the complimentary and interlinked theories within the rural academic field. Notably, the value of economic growth (SFBB implementation), geography (place-based) and sociology (human agency/capital) research (Section 3.2.4). For example, the interplay of NED/HVS analysis has identified new evidence of the value of IM information and knowledge flow and the connecting of core stakeholder assets throughout both ecosystems (Sections 6.8.1, 6.8.2 & 6.9). Thus, contributing a cross and multi-disciplinary study through NED analysis at the local level by consolidating the theoretical concepts and providing new IM analysis and findings.

7.4.2.4.2 Rural BB – CSF & failure factors (Section 3.8.2)

Ashmore et al. (2015, 2017), Diaz-Andrade & Urquhart (2009), Leong et al. (2016), Halseth et al. (2019), Wallace et al. (2015) identified CSFs of LDC, HC (IT skills), SC (bonding & bridging networks) and trust are required for successful broadband implementation (Section 3.5.1.1). Nevertheless, new human & social capital CSFs have been identified.

a) New evidence – HC proactive approach to "get the job done"

A proactive approach was identified as a new CSF within the supply ecosystem to "get the job done" (Section 6.3.3). It is also a hallmark of the LDCs to act on behalf of the rural community to "get the job done" (Section 6.5.2). The proactive approaches of both Mr. G and Mr. P are exhibited within this illustration. Bowen & Morris (2019) identified a proactive approach is required in Wales for rural farmers and SMEs to capitalise on the digital innovation. Henceforth, proactivity is required in Wales to enable both supply and demand opportunities.

b) New evidence – HC personal attributes & soft skills

New demand-side CSFs for LDCs are the personal attribute of altruism and the value of people & soft skills. Moreover, CSFs for the supply-side had not been discussed in

rural BB literature (e.g. value of altruism, people & soft skills). Hence, these are new HC contributions for both ecosystems.

c) New evidence – SC approaches to behaviour & networks

The approaches to SC behaviour is a new contribution to knowledge. The high-levels of HC & SC in both ecosystems and the friendly behaviour and high trust quotients exhibited by both parties resulted in the successful implementation of SFBB for SV-A.

d) New evidence - HC-SC interplay

The interplay and analysis of HC-SC, to this researcher's knowledge, is not discussed in rural BB literature. Thus, the creation of the Complex Ecosystem Assessment Tool (CEAT) is a new contribution to knowledge.

e) New evidence – Hindrances to HC productivity & SC collective action

To summarise the key findings are highlighted in bold:

- Hindrances to supply HC – **counterproductive personal attributes** – envy (wishing you had something someone else had), passivity (not acting), scepticism (doubt). Lack of skills (ability) & knowledge (don't know what to do, don't understand) (Section 6.3.7).
- Hindrances to supply SC – **counterproductive relationship behaviour** – authoritarian leadership (demanding people obey, refusing to allow freedom to act as they wish). Lack of community spirit (unfriendly & unsympathetic towards collective action). Lack of trust (do not trust ability to get things done). Lack of network (not working together & sharing information) - less bureaucracy (Section 6.4.10).
- Hindrances to demand HC – **counterproductive personal attributes** – not altruistic, what's in it for me attitude. Lack of skills (ability) – lack of people & soft skills (not friendly and do not communicate effectively) and lack of hard (IT skills). Lack of knowledge – do not understand complexities of network build (explicit), do not understand local community (tacit) (Section 6.5.5).
- Hindrances to demand SC – **counterproductive relationship behaviour** - Negative brand reputation for commercial suppliers and local authorities. Lack of

trust, lack of relationship behaviour and lack of network (not working together or sharing information) (Section 6.6.5).

f) New evidence – HC & SC – opportunity to mitigate failure element

Cybermoor (2016), Gerli & Whalley (2018) and Salemink & Strijker (2016) (Section 3.5.1.1, Table 3.9) identified the failure factor of competing ideals and potential powerplays that obstruct reaching the final few (Section 3.5.1.2.2).

The identification and value of altruism within both ecosystems can mitigate this failure element by removing competing ideals (e.g. mutual business & appropriability resolution thinking) and rebuild negative SC by assisting local authorities to allocate funds and reach the final few. These non-financial value-adds contribute to resolving these challenges by adopting a 21st-century friendly, altruistic and innovative mindset.

7.4.2.4.3 IM analysis (Section 3.8.5)

g) New evidence – People as IM hubs & roles – non-financial value-add

Allen & Cohen (1969) and Tidd & Bessant (2009) argued the value of gatekeepers, mediators & knowledge brokers to disseminate innovation information and knowledge flow throughout ecosystem-networks (Section 3.7.1). This research confirms this assertion and adds new evidence to rural BB literature by identifying the value of these people, as IM roles and hubs, within both supply & demand ecosystems. Rothwell (1974) identified product champions as CSFs for innovation projects. This study adds new evidence that product champions are CSFs for both supply & demand ecosystems and the interaction between the two produced successful results. LDCs have been identified as CSF for demand-ecosystem, but product champions have not been named for the supply-ecosystem. Thus, contributing new knowledge to the supply-ecosystem by identifying CSFs.

7.4.2.4.4 Human & social capital – Positive & negative (Section 3.8.6)

Schultz (1961), Becker (1994), Coleman (1988), Putnam (1993), Roche & Jakub (2017) have discussed the positive effects of HC & SC as assets/resources for investment (Section 3.6.5 & 3.6.6). Flora (2016) and Hallstrom et al. (2017) identify rural capital analysis for investment (Section 2.2.3 & 3.5.1). For example, when the LDCs HC skills and knowledge are invested this has a positive effect on the community (Section 5.8). Furthermore, when there is a high SC trust quotient within

a community, the "social fertility" makes it a positive area for investment (e.g. resources will not be squandered) (Roche & Jakub, 2017). A high trust quotient was identified in Splits-Ville (RSCAT, Section 5.8.4).

Portes (2014) argues the negative effects of social capital, but it is often in the context of cliques or closed networks within a community (e.g. criminal gangs & so forth). Nevertheless, this research has evidenced new negative effects to HC productivity & SC collective action to reach the final few (Section 6.9).

7.4.2.4.5 Four-fold capitals – Inputs (Section 3.8.7)

Roche & Jakub (2017) argued a 21st-century approach to business should consider non-financial as well as financial capital up front in the business model. The mutual business HVS approach extracted rich data showcasing the non-financial assets (inputs) in both ecosystems (Section 6.9). Thus, contributing new knowledge to this field.

7.4.2.4.6 NED/HVS conceptual framework (Section 3.8.8)

The NED (rural BB) and HVS (IM) framework has helped connect the core assets of several stakeholders for analysis (Section 6.9, Figure 6.26). To understand and map the positive and negative effects of the four-fold capital benefits has helped create the CEAT. Thus, adding new evidence and knowledge to both rural BB and IM literature. The following table synthesises the findings for potential intervention 2 (Table 7.2).

Table 7.2 Potential intervention (2) - related to literature/conceptual framework

Section	Core concept/ Conceptual Framework	Literature	Contributions
3.8.1	Academic field - NED, resilience & place-based (LM) theory	Terluin (2003) (Mixed endo/exogenous network & LM). Salemink, Strijker & Bosworth (2014, 2016) (NED for rural BB). Ashmore et al. (2015, 2017), Roberts et al. (2015, 2017). (Resilience – human agency, place-based).	**Confirms & extends** Value of economic growth (SFBB implementation), geography (place-based) & sociology (human agency/capital) are interlinked theoretical concepts. **New evidence** Cross & multi-disciplinary study - NED analysis at the local level consolidates the theoretical concepts & adds new IM analysis & findings to the literature.

3.8.2	Rural broadband	Ashmore (2016), Diaz-Andrade & Urquhart (2009), Leong (2016), Halseth (2019), Wallace et al. (2015). (CSFs LDC, HC, SC & trust). Bowen & Morris (2019) – proactive approach is required for demand stakeholders to capitalise on digital opportunities in Wales.	**Confirms & extends** Value of CSFs - LDC, HC leadership, IT skills, local tacit knowledge, SC networks & trust are required. **New evidence** Proactive approach is required for supply stakeholders to reach final few in Wales. **New evidence** LDC & new supply CSF- HC personal attributes of altruism, people & soft skills for both supply & demand ecosystems. **New evidence** Interplay of HC-SC to identify productive & counterproductive hindrances in complex ecosystem-networks.
3.8.5	Innovation Analysis (IM)	Allen & Cohen (1969) (Gatekeepers, knowledge flow). Tidd & Bessant (2009) (Hubs, ecosystems & networks). Rothwell (1974) (Product champions – ICT project CSFs).	**New evidence** Value of people as IM roles & hubs – gatekeepers, mediators, knowledge brokers, positive ecosystem-network interplay. **New evidence** New supply CSF – identified product champion in supply ecosystem to compliment value of LDC in demand ecosystem.
		Ley et al. (2014) (Living labs – non-financial value-add of mediators)	**Confirms & extends** Value of gatekeeper "Carol" as non-financial value-add to mediate ICT projects (Section 3.7.4.3).
3.8.6	Human & social capital theory (CSFs)	<u>Social capital:</u> Coleman (1988), Putnam (1993), Roche & Jakub (2017) (High trust quotient = social fertility for investment). <u>Rural BB literature:</u> Hallstrom et al. (2017) (Confirms non-financial capital required for investment to reach final few).	**New evidence** Positive HC & SC - high trust quotient for successful investment to reach final few. **New evidence** Rural Broadband Social Capital Assessment Tool (RSCAT) – identified high trust quotient in rural hamlet.

3.8.7	Four-fold capitals – inputs & outputs	Roche & Jakub (2017) (Four-fold capitals valued up front in business model)	**New evidence** Four-fold capital assets (inputs) had four-fold capital (outputs) for SV-A. Need to be identified & invested to reach final few.
3.8.8	Conceptual NED/HVS framework	Rural BB literature: Salemink, Strijker & Bosworth (2014, 2016) (NED at local-level) IM literature: Roche & Jakub (2017) (HVS analysis)	**New evidence** Value of NED & HVS analysis to connect the core assets of several stakeholders within both supply & demand ecosystems to bring a product to final few market.

** Critical Success Factors (CSFs), Hybrid Value System (HVS), Local Milieu or place-based theories (LM). Bold emphasis added to highlight new findings.*

In summary, Mr. G and Mr. P played significant NED and IM roles across both ecosystems. Mr. G's proactive role as a mediator on the demand-side, and knowledge broker for the supply-side, paid dividends for SV-A and vice versa for Mr. P. Henceforth, the value of NED engagement can result in "getting the job done" and reaching the final few (Figure 7.3). Moreover, there are multiple mutual learning & cooperative interplay opportunities within the complex ecosystems (Sections 6.8.1 & 6.8.2). How both ecosystem stakeholders engage to capitalise on the four-fold assets/resources available within their respective ecosystem-networks will depend on the proactive leadership and joined up approaches created to communicate the opportunities therein (Section 6.3, 6.4, 6.5 & 6.6). In contrast, counterproductive HC & SC will hinder the HC productivity & SC collective action to reach the goal of NGA access for rural communities and should be identified and mitigated as such (Section 6.3.7 & 6.4.7). One critical finding is the endogenous failure elements can be mitigated through positive HC productivity & SC collective action (e.g. altruism to reduce competing ideals or powerplays).

7.4.3 Final IM network analysis - Nation-level – Potential intervention (3)

There are a variety of potential interventions within the nation-level context and NED ecosystems (Section 5.6.1). These potential interventions encapsulate the five-cross cutting themes identified in (Section 5.11), the mutual learning & cooperative interplay of HC, SC and IM (Section 6.8.1) and the shared financial capital (SFC) opportunities (Section 6.8.2). If the telecommunications industry capitalises on the open innovation and co-creation thinking (Section 3.7.1 – 3.7.3) the opportunities are numerous (Section 5.6.4 & 5.11).

For example, the **HC labour shortage** is a newly identified barrier across the supply ecosystem (Section 5.5.2). Openreach is partnering with Careers Wales and investing in an engineer training centre in Newport, South Wales (Section 5.6, Figure 5.21). All the supply stakeholders could collaborate and partner to jointly fund or support the human capital investment required to deliver NGA access (Section 5.5.2). It is a long-term investment for all parties and would create jobs and upskill the local population for decades to come. **IM hubs & knowledge brokers** across the ecosystem-networks can activate the community social capital to identify and develop the individuals required to fulfil these roles (e.g. word of mouth advertising) (Section 5.4.5 & 6.8.1). Furthermore, demand stimulation is required to encourage investment (5.4.2). Business and digital skills training is required to promote take-up of NGA products and services (Section 5.7.2). Thus, the recommendation to **"educate & demonstrate"** (INT12, Welsh Government) can be maximised through collaborative efforts (e.g. Welsh Government & local authorities in partnership with Openreach & Altnets) to explain Industry 4.0 opportunities and barriers (Section 5.9).

The **complexities of the network build** is a core finding in this research (Section 5.5.1, 5.8.2, 5.10.2 & 5.11). FTTH user innovation and the value of HC, SC and EC can be utilised by all suppliers (Section 5.10.2). It all depends on the willingness of supply stakeholders to mutually learn and cooperate to capitalise on this local tacit knowledge (Section 5.11, 6.8.1, 6.8.2 & 6.9).

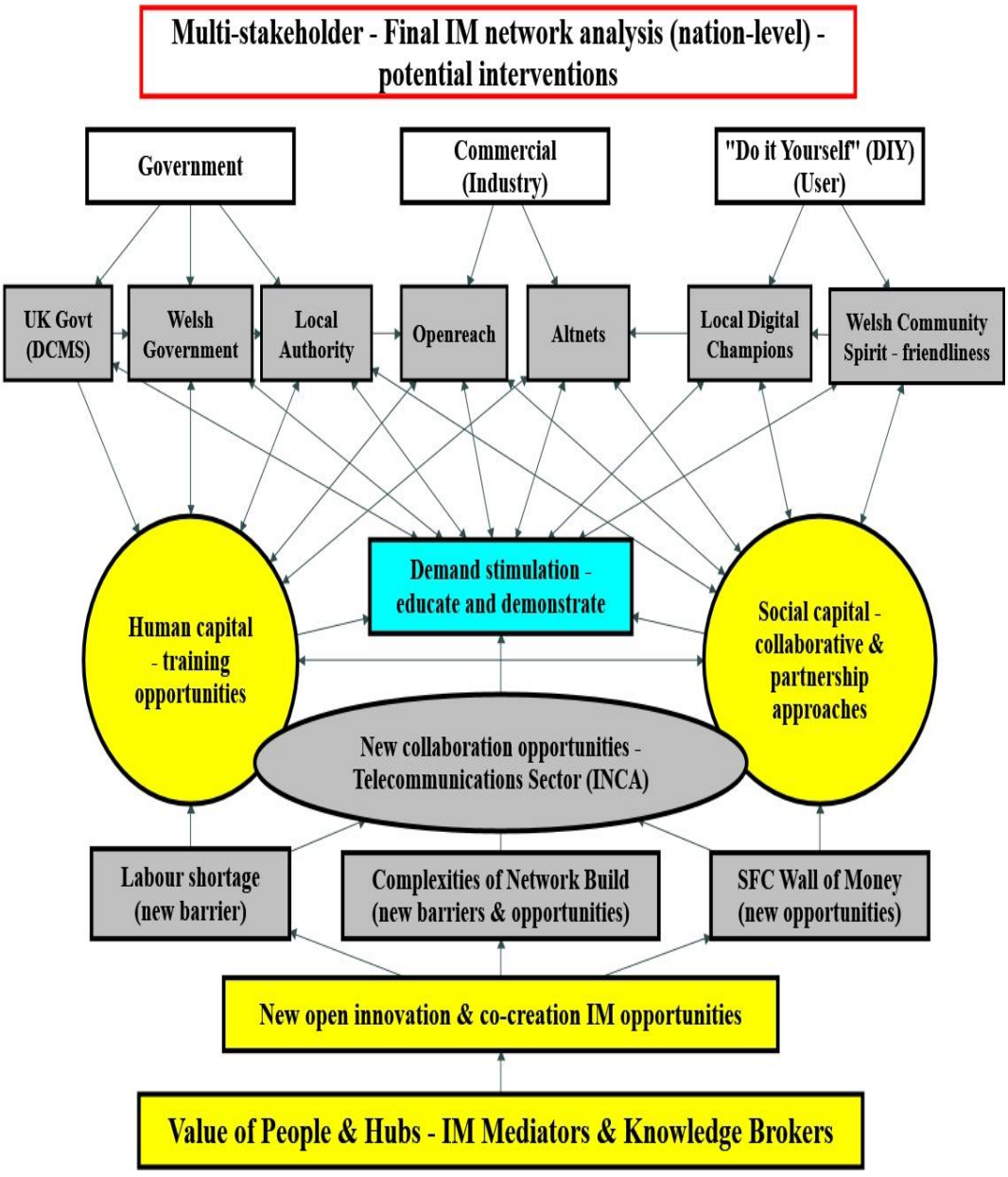
In addition, the **shared financial capital** investment opportunities are plentiful (Section 5.6.2 & 6.8.2). The mutual learning & cooperative interplay between the Altnets, Welsh Government and UK Government (DCMS) could procure additional private investment into the ecosystem therefore capitalising on the "Wall of Money" that is available for the telecommunication sector (Section 5.11 & 6.8.2).

For example, the Welsh Government can learn from the UK Government how to procure the human capital skills required to manage a Digital Infrastructure Investment Fund (DIIF) (Section 5.6.2, Figure 5.23). The IM roles of mediators & knowledge brokers are CSFs to help resolve the digital divide (Section 5.4.2, 5.4.3 & 6.4.5). This is not restricted to the supply ecosystem. OI and co-creation opportunities include the demand ecosystem (Section 5.8.1, 5.8.2, 5.10.2 & 6.6.2). Moreover, the **appropriability conundrum** (e.g. who profits from innovation) can be invalidated if

all stakeholders recognise the inherent non-financial value-add of the human & social capitals therein (Section 6.7 & 6.9).

Correspondingly, the **local authority can play a critical hub role** to activate the clawback clause and provide gap funding for rural community DIY options or Openreach CFP partnering if shortfalls are required (Section 5.8.1 & 6.8.1). A final network analysis for the nation-level and complex ecosystem-network opportunities and challenges for potential OI and co-creation interventions are summarised in (Figure 7.4).

Figure 7.4 Innovation (IM) analysis (nation-level) - potential intervention (3)



In summary, the OI and co-creation opportunities (e.g. human & social capital engagement) are abundant within the NED ecosystem. How the relevant stakeholders capitalise on the human, social, environmental and shared financial capital available within the ecosystem-networks will determine whether the demand awareness to "educate & demonstrate" the capabilities of Industry 4.0 and NGA access will be successful, or not. Equally, the HC labour shortage, complexities of full fibre network build, and SFC investment opportunities for new business models and collaborative action are open to negotiation. It is this researcher's assertion that the final few should be reached with the abundant capital available within the ecosystem.

7.4.3.1 Discussion – Related literature & conceptual framework

This intervention focuses primarily on the IM analysis and how it contributes to rural BB literature. The academic field (3.8.1), human & social capital (3.8.6), four-fold capitals (3.8.7) core concepts have been discussed in potential interventions 1 and 2 and therefore will not be duplicated.

7.4.3.1.1 Rural BB – HC, SC & SFC in system (Section 3.8.2)

Hosseini et al. (2018) smart town "Open Innovation Framework" incorporated IM analysis to rural BB studies. This study extends and adds new IM analysis to rural BB literature. This is important because it allows the investigation of open innovation (OI) opportunities (between internal & external stakeholders), co-creation opportunities (between government, industry & users) and multi-stakeholder (multi-player) engagement within a dynamic networked-ecosystem (Chesbrough (2017), Von Hippel (2005), Schuurman (2015), Tidd & Bessant (2009) in Sections 3.7.2 – 3.7.4). This is important because it adds a new 21st-century way of thinking about the problem area and uncovers new opportunities in how to reach the final few.

7.4.3.1.2 IM analysis – The digital age - new evidence (Section 3.8.5)

Bessant (2015) argued the context has changed and the world is now a system, networked and global (Section 3.3.5). Strands of knowledge exist inside and outside and weaving these together creates value. Ecosystems, networks and knowledge flow is dynamic not static. New roles such as gatekeepers & knowledge brokers are required to engage in 21st-century open innovation thinking (Section 3.3.5). This study encapsulates this new thinking by capturing complex ecosystem-networks and dynamic knowledge flow through mediators (or gatekeepers) and knowledge brokers.

The IM analysis is important because it provides a new lens from which to observe the digital divide phenomenon. Thus, contributing new knowledge to the field.

a) Value of people & hubs – Mapped analysis

The introduction and value of IM mediators & knowledge brokers has been discussed at length in potential interventions 1 and 2. Nevertheless, the mapped nation-level analysis allows the reader to evaluate the multiple HC, SC, SFC and IM opportunities therein (Figure 7.4). Thus, the **mapped complex ecosystem-network IM analysis** provides new evidence to the rural BB literature.

b) Value of IM analysis – Systems view

Tidd & Bessant (2009) argued 21st century innovation is a multi-player game and need to adopt a *systems view* to include other players and work together in networks (Section 3.7). Rothwell (1994) analysed the progression of supply & demand models up to the latest fifth generation and named it as a "systems integration & networking" process (Section 3.7.1). This is important because how do you engage multiple-stakeholders to work together in networks? This study has extended this thinking to incorporate OI, co-creation and multi-stakeholder "system integration & networking" analysis within a NED ecosystem. **The mapped IM analysis** illustrates this systems view and how the multiple players can collaborate and work together within complex ecosystem-networks. Thus, contributing new knowledge to the academic field, rural BB and IM literature.

c) Value of IM analysis – Open innovation & co-creation/user innovation

OI engages with internal & external relationships, knowledge transfers and trust (Chesbrough, 2017; West et al., 2014). Co-creation and user innovation includes education, skills and tacit knowledge (Von Hippel, 2005). Von Hippel (2015) argued collaboration with users "democratises innovation" and the "free reveal" of user innovation is a non-financial value-add of motivation and reputational enhancement (Section 3.7.3). This assertion was validated by both LDCs motives to support SV-A & B (Section 5.8.5). This is important because it captures and illustrates the value of human & social capital engagement and why both capitals need to be appreciated, valued and analysed for opportunities to reach the final few.

d) Value of IM analysis – New business models

Chesbrough (2010, 2017) & Teece (2010) argued the future of open innovation (OI) involves business model innovation to include **multiple collaborations, communities and entire ecosystems**. The mapped IM analysis of the nation (macro) level captures this kind of thinking and the collaborative opportunities therein to reach the final few. Roche & Jakub (2017) argued a new and more holistic business model is required for 21st-century thinking and suggest a counter-intuitive approach by valuing non-financial capital alongside financial capital measurements (Section 3.7.1). This is important because developing new or alternative business models is required in the rural BB literature (Section 3.5.1) and the World Economic Forum (WEF) recommendation (Section 3.6.1) in how to reach the final few. Hence, this new kind of thinking alongside a mapped IM analysis showcases the new business model opportunities therein.

e) Value of IM analysis - Multi-stakeholder engagement (Macro-level)

Pascu & Van Lieshout (2009) argued multi-player and multi-stakeholder engagement can include users in public-private partnerships (PPPs). The authors argued PPP's (government, industry, users) can be created for a specific purpose and include a social dimension to resolve social dilemmas and challenges (Section 3.7.4.2). Moreover, Schuurman (2015) argued macro-level engagement can include a constellation of PPPs as open innovation (OI) for knowledge transfer between organisations (Table 3.12).

The mapped IM analysis provides an illustration of how these collaborations can manifest. This is important because multi-stakeholder engagement is required for 21st-century business (Tidd & Bessant, 2009). Thus, how to engage government, industry and users in a PPP contributes new thinking to the problem area. PPPs are traditionally government and industry collaborations but living lab analysis and combining OI and user innovation provides additional avenues for collaboration. Particularly because there is a social dimension to rural BB (e.g. reducing geography, isolation and so forth) which has been exacerbated by COVID19 (Section 5.8.8). Thus, this mapped nation (macro) IM analysis showcases the multiple opportunities for government, industry and user collaboration.

7.4.3.1.3 Exogenous supply ecosystem (Section 3.8.3)

Overall drivers, opportunities, barriers, failure and CSFs will be discussed in revised conceptual framework (Section 7.5). Nevertheless, for illustrative purposes the following new opportunities and barriers for supply will be discussed.

f) <u>New barrier - Complexities of network build</u>

Stranded assets, timebound constraints and Openreach anomalies can be mitigated through local authority and rural community engagement (Section 5.5.1). The **IM mapped analysis** summarises the 21st century thinking to engage with NED ecosystems at the local-level.

g) <u>New barrier - HC labour shortage</u>

The HC labour shortage could curtail the roll-out of NGA (Section 5.5.2). Hence, an open and collaborative effort to resolve this challenge could be mitigated through NED IM analysis of the inherent opportunities within both ecosystems.

h) <u>New opportunities – Collaborative engagement</u>

Multiple commercial supplier collaboration opportunities were identified (Section 5.6). This is important because how Openreach and the Altnets engage with local authorities and rural communities will require 21st century OI and co-creation thinking to reach the final few. The IM mapped analysis provides an illustration of the multiple opportunities available within both ecosystems.

i) <u>New opportunities – Multiple SFC opportunities</u>

As previously identified in potential interventions 1 and 2, the shared financial capital (SFC) opportunities are numerous (Section 5.6 & 6.8.2). How the supply & demand stakeholders engage to allocate these financial resources is to be determined. Nevertheless, if NED stakeholders engage at the local authority-level, and value the LDCs, EOs and the Welsh Community Spirit, much can be done to resolve the digital divide (Section 6.8.1, Figure 6.23).

7.4.3.1.4 Endogenous demand ecosystem (Section 3.8.4)

Overall drivers, opportunities, barriers, failure and CSFs will be discussed in revised conceptual framework (Section 7.5). Nevertheless, for illustrative purposes the following new opportunities for demand will be discussed.

j) New opportunities – Demand stimulation – "educate & demonstrate"

Rural adopters need to understand relevance, relative advantage, self-efficacy and utility outcomes (Whitacre, 2010; Dobson et al., 2013; Peronard & Just, 2011; Rao Hill et al., 2011 in Section 3.5.2.3). Mr. P's experience to "educate & demonstrate" (Section 5.7.2) could be an OI and co-creation collaboration opportunities amongst all stakeholders. This is important because only two interviewees had heard of Industry 4.0 (Section 7.2.2). This lack of knowledge about the opportunities being presented can affect demand and therefore investment in the final few and hard to reach areas (Section 5.9).

k) New opportunity – Word-of-mouth – free advertising

The value of free of mouth advertising was identified by PCC EO's (Section 5.4.3). Moreover, the value of Welsh Community Spirit in both demand & supply ecosystems is an important asset and resource to be utilised (Sections 6.4.4 & 6.6.3). This is important because the value of non-financial capital can produce results in the market (Lin, 2002).

7.4.3.1.5 NED/HVS conceptual framework (Section 3.8.8)

The NED/HVS analysis identified new Industry 4.0 drivers & opportunities (Section 5.9.1), Agri-tech opportunities for Wales (Section 5.9.2) and new barriers (HC shortage & complexities of network build). Nonetheless, the IM mapped NED analysis can help mitigate these opportunities and challenges through proactive HC productivity & SC collective action provided there is a will for stakeholders to engage in 21st-century IM thinking. The following table synthesises the findings for potential intervention 3 (Table 7.3).

Table 7.3 Potential intervention (3) - related to literature/conceptual framework

Section	Conceptual Framework – core concepts	Literature	Contributions
3.8.2	Rural broadband	Hosseini et al. (2018) (Smart town open innovation framework analysis).	**Confirms & extends** Extends OI & system thinking to include co-creation & multi-stakeholder analysis within local NED. **New evidence** Value of IM analysis to rural BB.

3.8.5	Innovation analysis (IM)	Bessant (2015) (Digital age – networked, multi-player game).	**New evidence** 21st-century multi-player, systems thinking required for NED analysis.
		Chesbrough (2017) (Open innovation – internal & external network collaboration).	**Confirms & extends** OI internal/external networks. HC & SC engagement required to "think outside the box". **New evidence** Value of IM thinking to rural BB literature.
		Von Hippel (2005) (Co-creation/user innovation) Teece (2006) (Appropriability conundrum)	**New evidence** Co-creation/user innovation (DIY efforts) – HC & SC collaboration - benefits not always financial.
		Teece (2010) & Chesbrough (2010) (New business model innovation) Roche & Jakub (2017) (Counterintuitive approach – value non-financial capital alongside financial capital).	**New evidence** New business models – to include multiple collaborations, communities & entire ecosystems to reach final few.
		Rothwell (1994) (Supply & demand – fifth-generation - systems integration & networking)	**New evidence** Value of IM thinking to rural BB. IM mapped analysis – systems integration, networking. Multi-player game to reach final few.
		Schultz (1961), Becker (1994) (Human capital – skills, knowledge) Coleman (1988), Putnam (1993) (Social capital – networks & trust)	**New evidence** Value of IM thinking to rural BB. OI, co-creation & multi-stakeholder as human & social capital engagement required to reach final few.

3.8.8	Conceptual NED/HVS framework	Rural BB literature: Salemink, Strijker, Bosworth (2014, 2016) (Rural NED analysis at local-level). IM literature: Roche & Jakub (2017) (HVS approach).	**New evidence** Value of NED/HVS analysis – to map ecosystem & identify and connect core assets of several stakeholders to get the product to final few market. **New evidence** New 21st-century paradigmatic thinking required – to value non-financial capital & financial capital upfront in business model.

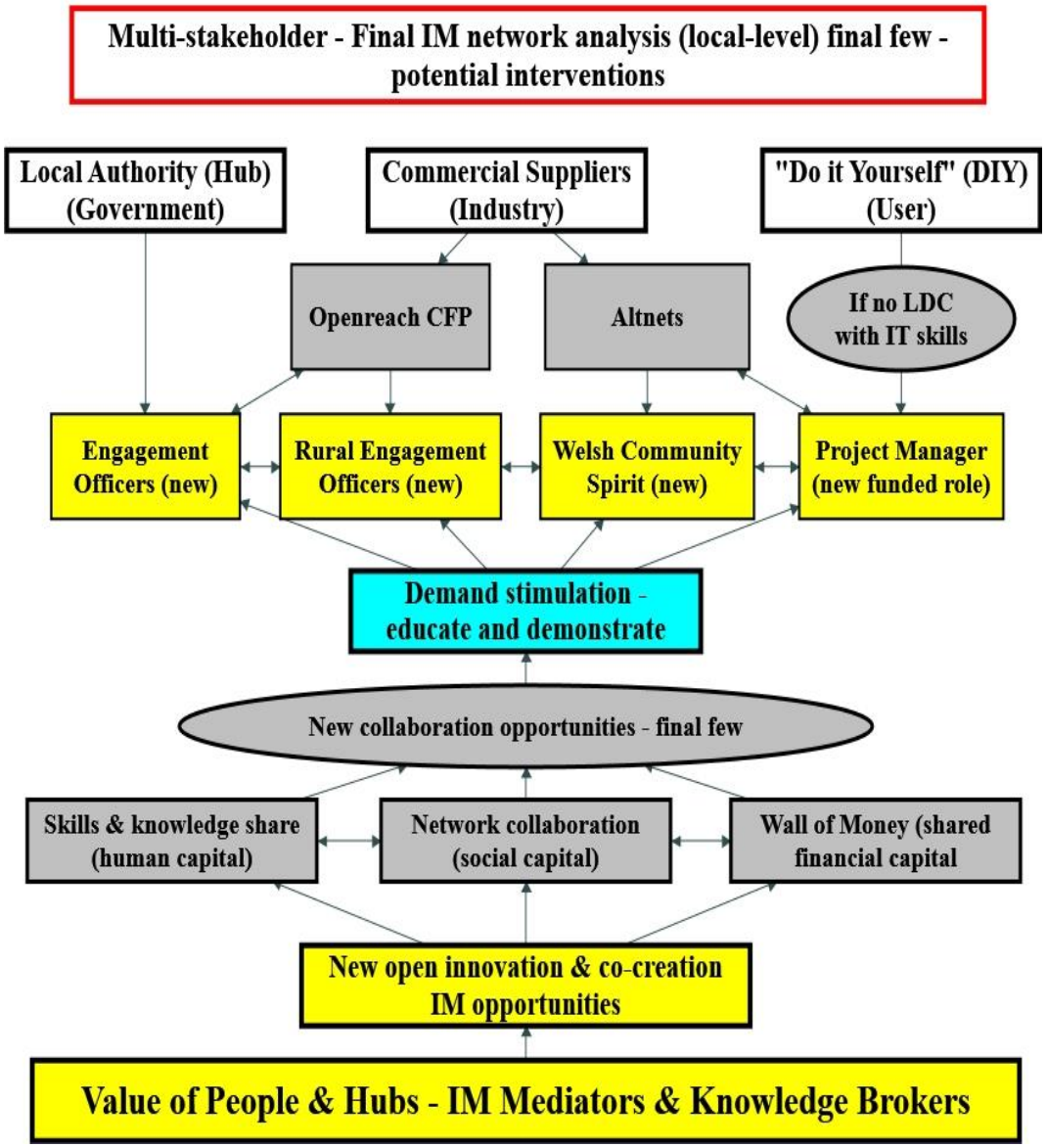
** Critical Success Factors (CSFs), Hybrid Value System (HVS), Local Milieu or place-based theories (LM). Bold emphasis added to highlight new findings.*

To conclude, there are multiple OI and co-creation opportunities within a complex ecosystem for multi-stakeholder engagement. Potential PPPs can be formed between industry, government and users, alongside the four-fold capital model, to ensure stakeholder capital is considered "up front" in the business model. One critical finding is the suggestion for new innovative business models to include multiple stakeholders, communities and entire ecosystems which is illustrated by this mapped analysis. This kind of new paradigmatic thinking is required for 21st-century business to get the job done and reach the final few.

7.4.4 Final IM network analysis - Local-level – Potential intervention (4)

The micro context of the demand ecosystem equally presents OI and co-creation opportunities but at the local-level (Section 6.8.1 & 6.8.2). The IM role of knowledge brokers & mediators to disseminate information, including demand stimulation, and "First in Wales" initiatives to reach the final few can aid local communities in a variety of ways. Examples of OI and co-creation collaboration include the positive SC collective action between the local authority and Openreach Community Fibre Partnerships (Section 7.4.1) to support rural communities and allocate gap funding. The engagement of the Welsh Community Spirit as a valuable non-financial resource (Section 6.3.4 & 6.6.3). The potential to fund a Project Manager-type role to assume the coordination role to act as liaison for rural communities who want to access DIY options, particularly if the government initiatives fail for any reason (Section 5.11 & 6.8.1). Multiple OI and co-creation opportunities are illustrated in the final local-level IM network analysis (Figure 7.5).

Figure 7.5 Innovation (IM) analysis (local-level) - potential intervention (4)



In summary, there are multiple OI and co-creation opportunities (e.g. human & social capital engagement) that exist within the local-level that mirror the activities at the nation-level. These activities revealed shared-value within both macro and micro contexts (Section 7.4.3 & 7.4.4). How the local authorities (government), commercial suppliers (industry) and rural communities (users) engage in these processes is to be determined, which is an opportunity for future research (Chapter Eight). If the knowledge brokers & mediators, both as people and hubs, can be identified, encouraged and empowered to collaborate, then the complex ecosystems HC productivity & SC collective action to reach the final few can be realised. Conversely, the counterproductive barriers need to be identified to unlock the system.

7.4.4.1 Discussion – Related to literature & conceptual framework

This intervention discusses the IM opportunities at the local (micro) level and how it contributes to rural BB literature. The value of 21st-century thinking, IM mediator, knowledge brokers and centralised hubs has been discussed in nation-level analysis and will not be duplicated in this section.

7.4.4.1.1 Rural broadband – Local-level studies (Section 3.8.2)

Rural partnership is the act of bringing together public and private resources and more research at the local level was required (Erdiaw-Kwasie & Alam, 2016; Gallardo, 2018 in Section 3.5.1.3). The complexities of multi-faceted rural community ecosystems call for multi-stakeholders to work together (Section 3.5.1.4). Furthermore, quantitative studies required more micro-level and small geography studies to understand grant impacts (Section 3.5.3). This qualitative multi-method unique case study fulfils the small geography gap with deep rural hamlet analysis and evidences the lack of grant impact for SV-B.

7.4.4.1.2 Exogenous supply ecosystem (Section 3.8.3)

Overall drivers, opportunities, barriers, failure and CSFs will be discussed in revised conceptual framework (Section 7.5). Nevertheless, for illustrative purposes the following new opportunities for supply will be discussed.

a) New opportunities – New IM roles & hubs

The surprise finding of the introduction of rural Engagement Officers (EOs) for both the local authority and Openreach is a new supply opportunity to reach the final few (Section 7.3.2). This is important, because the value of altruism, people & soft skills and local tacit knowledge (e.g. spectrum of human behaviour) has already been discussed as new CSFs and a new contribution to knowledge.

b) New opportunities – World Economic Forum (WEF) – local-level

To overcome supply barriers, the WEF (2016) recommended focusing on the local area and to identify best practice cooperation, coordination and collaboration amongst multiple stakeholders (Section 3.6.3). The newly identified Taskforce and PCC initiatives fulfils this role, and this research provides the evidence of a local collaborative effort is required to reach the final few (Section 6.8.1, Figure 6.23) and potential intervention 1 (Section 7.4.1).

c) New opportunity – Dynamic Purchasing System (DPS)

The feedback loops to DCMS to provide greater flexibility with funding resulted in the new Dynamic Purchasing System (DPS) to work specifically with local-authorities and reach the final few (Section 5.6.7). This is important because the information and knowledge flow amongst the supply-ecosystem is getting to the local-authority level to resolve the problem. Nonetheless, it is yet to be determined how proactive the local authorities will be to capitalise on these new, and older, initiatives (Section 6.8.2, Figure 6.25).

d) New opportunity – Remove barriers & failure factors

Barriers and failure factors included distrust, misallocation of funds and potential powerplays (Section 3.6.3). The opportunity to remove these barriers was discussed in nation-findings and mirrored at local level (e.g. non-financial value-add of altruism & friendly Welsh Community Spirit to mitigate barriers).

7.4.4.1.3 Endogenous demand ecosystem (Section 3.8.4)

Overall drivers, opportunities, barriers, failure and CSFs will be reviewed in the revised conceptual framework (Section 7.5). Nevertheless, for illustrative purposes the following new opportunities for demand will be discussed.

e) New opportunities – Failure factors – Clawback clause

The failure to allocate the clawback clause funding was discussed in potential intervention 1. Nevertheless, this study showcases the multiple opportunities to allocate various funding options at the local authority level (Section 6.8.2, Figure 6.25).

f) New opportunities – "Do it Yourself" (DIY)

A potential new Project Manager funded role for communities who lack the necessary HC skills to implement community-led options could be forthcoming from Welsh Government or the local-authority (Section 6.3.7). This is important because it is a potentially new opportunity to support local communities who opt for a DIY approach but who lack an LDC to drive forward the project.

7.4.4.4 IM Analysis – OI, co-creation & multi-stakeholders (Section 3.8.5)

Similar to the nation-level, Bessant (2015), Chesbrough (2017), Von Hippel (2011), Teece (2010), Tidd & Bessant (2009) suggest the information and knowledge flow

throughout both ecosystems is required for 21st century business thinking (Section 3.7.1 – 3.7.4). The local-level case study findings (Section 6.8.1) alongside this wider analysis on how the complex ecosystem-networks can collaborate at the local-level to reach the final few. Moreover, the HVS analysis and connecting core assets of several stakeholders contributes to new knowledge (Section 6.9. Figure 6.26).

g) New evidence - Multi-stakeholder engagement – project (meso-level)

Schuurman (2015) argued a project (Meso-level) living lab is open and user innovation and characterised by active user involvement, co-creation, multi-method and multi-stakeholder (Section 3.7.4.2, Table 3.12). The previous (Figure 7.4) showcases these opportunities at the project-level as opposed to the macro-level in nation analysis.

The following summary synthesises the findings. The local-level mirrors many of the nation-level and potential 1 and 2 findings. Hence, the following table focuses on new evidence (Table 7.4).

Table 7.4 Potential intervention (4) - related to literature/conceptual framework

Section	Core Concepts/ Conceptual Framework	Literature	New evidence
3.8.2	Rural Broadband	Erdiaw-Kwasie & Alam (2016), Gallardo (2018) (Local-level studies required).	**New evidence** More local-level, small geography studies required. This research fills the gap.
3.8.3	Exogenous supply ecosystem	New opportunity: (local-level) – new IM roles & hubs.	**New evidence** New Engagement Officer roles (local-level) – Local-authority & Openreach.
		New opportunity: WEF (2016) (local-level) identify best practice cooperation, coordination & collaboration amongst multiple stakeholders	**New evidence** First in Wales (local-authority level) – Taskforce & PCC
		New opportunity: (Local-level) remove barriers & failure factors	**New evidence** Similar to nation-level – value of non-financial value-add of altruism, Welsh Community Spirit to **mitigate** distrust, powerplays & misallocation of funds.

3.8.4	Endogenous demand ecosystem	New opportunity: Salemink & Strijker (2016) - 8-stage model (Section 3.5.1, Table 3.9).	**New evidence** Provide funding for rural community Project Manager to action eight-stage model.
3.8.5	Innovation Analysis (IM)	Schuurman (2015) (Meso-Project level) (Section 3.7.4.2, Table 3.12)	**New evidence** OI & user innovation living lab - characterised by active user involvement, co-creation, multi-method & multi-stakeholder
3.8.7	Four-fold capitals – inputs & outputs	IM literature: Roche & Jakub (2017) (Social fertility assessment)	**New finding** RSCAT analysis – rural hamlet - SC trust quotient high – good for investment.
3.8.8	Conceptual NED/HVS framework	Rural BB: Salemink, Strijker, Bosworth (2014, 2016) (Gap - rural NED analysis at local-level). IM literature: Roche & Jakub (2017) (HVS approach).	**New evidence** Value of HVS - connecting core assets of several stakeholders to reach final few. **New evidence** New 21st-century paradigmatic thinking required to "think outside the box" and reach the final few.

** Critical Success Factors (CSFs), Hybrid Value System (HVS), Local Milieu or place-based theories (LM). Bold emphasis added to highlight new findings.*

To conclude, the findings are similar to the nation-level (Table 7.3), but with a few exceptions. The local authority plays a critical role at the local-level to allocate funding. The friendly Welsh Community Spirit is a non-financial value-add in both ecosystems and should be recognised as an asset/resource in reaching the final few. Finally, new 21st century paradigmatic thinking is required to ensure stakeholder capital is considered "up front" in the business model to maximise opportunities and reach the final few.

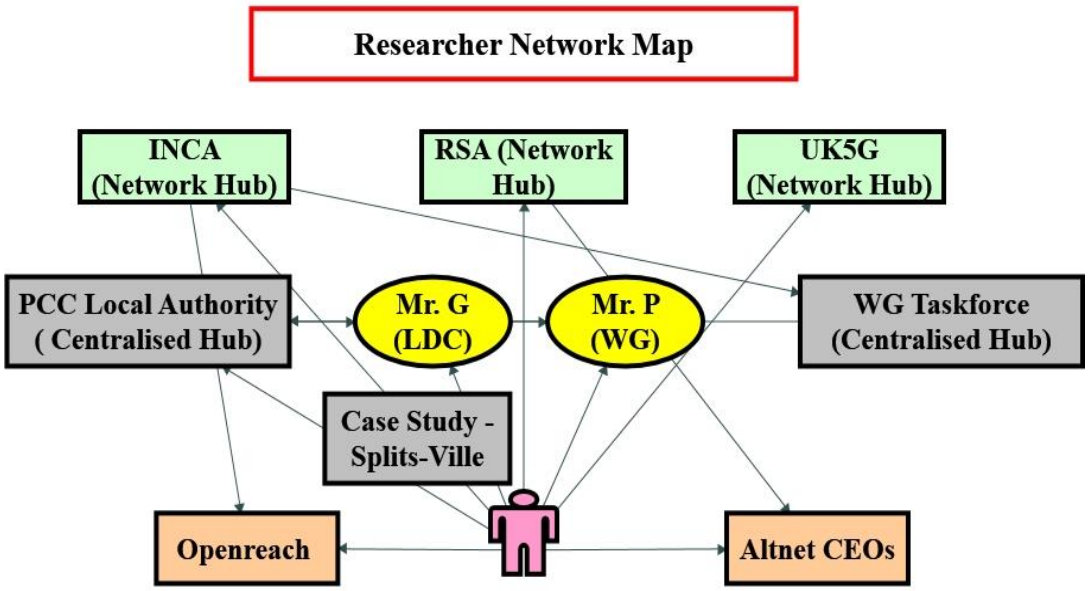
7.4.5 The value of network visualisation tools – Reflective research map

A final analysis and discussion point is the value of using network visualisation tools to communicate how to disseminate best practice and knowledge flow throughout a complex ecosystem-network. As an example, the following diagram explains how this researcher moved within the ecosystem to develop relationships with stakeholders (e.g. Mr. G & Mr. P), acquire knowledge (e.g. Network Hubs, such as INCA, RSA & UK5G conferences), and engagement with Centralised Hubs (e.g. Welsh Government

Taskforce & PCC Local Authority). The following illustration shows the value of human & social capital through people, hubs and networks (Figure 7.6).

The original introduction to Mr. G, was through a separate contact in the PCC Local Authority during the 2016 Microbusiness Pilot Project (Section 2.3.6.3). The introduction to Mr. G, lead to an introduction to Mr. P. By attending the INCA Conference (May 2019) this led to introductions to Openreach and the Welsh Government which resulted in the invitation to attend the Taskforce (Section 5.2). The RSA Conference (May 2019) provided numerous contacts and knowledge within Wales's academic and telecommunications industry. The UK5G Conference (June 2019), introduced this research into the machinations of 5G, and the UK Government DCMS funding proposals to develop consortiums for collaborative partnerships to develop the technology and use cases (Section 5.2.4). The task of identifying all the network linkages, hubs and actors that contributed to the study, so that they could be visualised, was itself a powerful tool for reflective analysis. Thus, providing a further source of data for triangulation.

Figure 7.6 The value of network visualisation tools – reflective research map



In summary, it is the vast amount of human & social capital within a defined ecosystem that provided the knowledge flow, relationships, and networks to deliver this thesis. Henceforth, network mapping can provide in-depth analysis into the value of capital resources embedded within any defined complex ecosystem-network.

7.5 Revised Conceptual Framework – Outcomes

The original plan for this research was a mixed-method supply and demand study at the local-level. However, the introduction of the Engagement Officers (EOs) to the case study area changed the focus of this research and the demand assessment was moved to future research (Appendix N).

As a result of these modifications, the conceptual framework was revised (Section 3.8.8). The original conceptual framework as a NED exploration of both supply and demand ecosystems at the local-level remains valid. Nevertheless, the outcomes have been revised as a result of the analysis.

Overall, the original supply and demand drivers, opportunities, barriers, failure factors and CSFs identified in the literature were confirmed in the expected findings (Section 7.3.1) and reiterated below (Section 3.8.3 & 3.8.4). Nonetheless, new drivers, opportunities, barriers, CSFs and failure factors have been identified as a result of this research and will be discussed below in (Section 7.5.1 – 7.5.9).

1. Previous concepts - Exogenous supply ecosystem (Section 3.8.3)

To reiterate the previous exogenous supply ecosystem drivers, opportunities, barriers and failure factors identified in the literature (Section 3.8.3). A summary per objective is restated below (Table 7.5) and was discussed throughout the potential intervention areas (Section 7.4.1 – 7.4.4).

Table 7.5 Summary of previous exogenous supply concepts in literature

Objective	Previous supply concepts	Section
2A	Drivers & Opportunities – Industry 4.0 – entrepreneur creative destruction opportunities, quality of life.	3.6.1
2B	Drivers & Opportunities – Supply – barrier busting taskforce, State Aid, new business models, local govt to allocate funds.	3.6.2
2C	Barriers – Supply – Government (cost, geography, reliable backhauls). Commercial (cost, geography, distrust).	3.6.3
	Failure Factors – State aid – compressed timelines, bureaucracy, misallocation of funds, negative SC, powerplays.	

2. Previous - Endogenous demand ecosystem (Section 3.8.4)

To reiterate the previous endogenous demand ecosystem drivers, opportunities, barriers, failure factors and CSFs identified in the literature (Section 3.8.4). A summary per objective is restated below.

Table 7.6 Summary of previous endogenous demand concepts in literature

Objective	Previous demand concepts	Section
2A	Drivers & Opportunities – Industry 4.0 – teleworking, education, remove geography limits, enable & support economic transactions, provide innovation opportunities.	3.6.1
2B	Drivers & Opportunities – Demand – Clawback clause, IT clubs	3.6.2
2C	Barriers – Demand – Community (distrust, finances, government failings, lack of leadership, skills). Individual (age, cost, education, lack of skills).	3.6.3
2D	CSFs – Demand – LDCs, HC/IT, SC & Trust	3.6.4

3. New findings - Exogenous supply & endogenous demand ecosystems

The new supply and demand ecosystem drivers, opportunities, barriers, failure factors and CSFs identified in this thesis are applied to the revised conceptual framework (Figure 7.7). The following summarises the new findings by chapter and section headings in relation to answering the RQs.

7.5.1 New driver – Supply

Chapter Five identified new drivers for supply and were discussed in potential intervention 1 (Section 7.4.1). Summarised below in each section to answer RQs (Table 7.7).

Table 7.7 Summary of new drivers – supply ecosystem

Section	Summary of new findings	RQs
5.8.8	Enforced effects of COVID19 to reach final few.	RQ2
5.6.5 & 7.4.1	Local-authority – action clawback clause funding for stranded assets.	RQ1&2
5.8.3 & 7.4.1	Provide community with quality of life & IM opportunities – realised for SV-A but not SV-B.	RQ1&2

7.5.2 New opportunities – Supply

Chapter Five identified multiple new opportunities for supply and are summarised below in each section to answer RQs (Table 7.8).

Table 7.8 Summary of new opportunities – supply ecosystem

Section	Summary of new findings	RQs
5.4.2.4	PCC - 70% take-up rate – Demand higher than expected – feedback loops – aids investment.	RQ2
5.6.1	Openreach Community Fibre Partnership (CFP) collaboration – new partnership roles & centralised hubs to reach final few.	RQ1-3
5.6.3	Altnets – Collaboration opportunities with Openreach.	RQ2
5.6.5	Wall of Money - local authority-level.	RQ1&2
5.6.6	Potential new Digital Infrastructure Investment Fund (DIIF).	RQ1&3
5.6.7	Dynamic Purchasing System (DPS) – new local authority collaboration.	RQ1-3
5.10.2.4	New Do-It-Yourself (DIY) options.	RQ1&3
5.10.2.6	FTTH – HC, SC & EC of contractor collaboration.	RQ1&2

7.5.3 New barriers & failure factors – Supply

Chapter Five identified new barriers and failure factors not previously discussed in rural broadband literature and summarised below in each section to answer RQs (Table 7.9).

Table 7.9 Summary of new barriers & failure factors – supply ecosystem

Section	Summary of new findings	RQs
5.4.1.3 & 5.5.1	Complexities of network build – stranded assets, time-bound contracts, local authority-level to allocate funding.	RQ2
5.5.2	Labour shortage – lack of HC.	RQ1
5.8.6	Openreach anomaly – legacy issues.	RQ2

7.5.4 New critical success factors (CSFs) – Supply

Chapter Six detailed analysis and more granular detail in the definitions identified multiple new CSFs and summarised below in each section to answer RQs (Table 7.10).

Table 7.10 Summary of new CSFs – supply ecosystem

Section	Summary of new findings	RQs
6.3.2 & 7.4.2	HC Personal attributes - proactive approach – driven, enthusiastic, empowerment.	RQ1
6.3.5 & 7.4.2	HC People & soft skills – deal in friendly and effective way to achieve good results; ability to communicate and work well together.	RQ1
6.3.6 & 7.4.2	HC Local tacit knowledge (EOs) – Spectrum of human behaviour - Altruism.	RQ1
6.4.2 & 7.4.2	SC Trust – extended definition – confidence, mutual respect, transparency, right environment.	RQ1
6.4.4 & 7.4.2	SC Approach to relationship behaviour – better to engage than enrage.	RQ1
6.4.5 & 7.4.2	SC Value relationship behaviour – Community Spirit; friendly & understanding.	RQ1
6.4.6 & 7.4.2	SC Approach & value networks – collaborative, joined-up, partnership approach.	RQ1
6.4.8 & 7.4.2	Identification of IM mediators & knowledge brokers – freely disseminate explicit & tacit knowledge for betterment of others: conflict resolution.	RQ1&2
6.4.9 & 7.4.2	Identification of IM hubs – new critical hub is local authority.	RQ1-3

7.5.5 New & confirmed opportunities - Demand

Chapter Five confirmed previous rural broadband assertions and identified a new opportunity to "educate & demonstrate" Industry 4.0 opportunities to rural communities through nation and local level potential interventions (Section 7.4.3 & 7.4.4). Summarised below in each section to answer RQs (Table 7.11).

Table 7.11 Summary of confirmed & new opportunities – demand ecosystem

Section	Summary of confirmed & new findings	RQs
5.7.2 & 7.4.4	Demand & skills training – "educate & demonstrate" (new).	RQ1&2
5.8.3	Four-fold capital benefits (confirms previous studies).	RQ1
5.8.3.1	MB new business models (confirms innovation opportunities).	RQ2
5.8.3.2	Individual growth (HC & SC) (confirms human agency).	RQ1
5.9.1	Agri-tech (confirms Industry 4.0 innovation opportunities).	RQ2

7.5.6 New & confirmed barriers and failure factors – Demand

Chapter Five identified new barriers and failure factors which were discussed in potential intervention 1 (Section 7.4.1). Summarised below in each section to answer RQs (Table 7.12).

Table 7.12 Summary of new barriers & failure factors – demand ecosystem

Section	Summary of confirmed & new findings	RQs
5.4.2.1	Challenges identified in Pembrokeshire – quality of schools, healthcare & infrastructure can hinder in/out migration alongside NGA access (new).	RQ2
5.8.2.1 & 7.4.1	Negative brand reputation (confirmed commercial & local authority).	RQ2
5.8.2.3 & 7.4.1	No opportunity to present business case to local authority to acquire funding (new).	RQ2
5.8.2.3 & 7.4.1	No local authority centralised hub to allocate funding (new).	RQ1&2
5.9.1	Only two interviewees had heard of Industry 4.0 but rather IOT, digital revolution (new).	RQ2

7.5.7 New CSFs – Demand

Chapter Six identified new demand CSFs which are new contributions to knowledge. Summarised below in each section to answer RQs (Table 7.13).

Table 7.13 Summary of new CSFs – demand ecosystem

Section	Summary of new findings	RQs
6.5.3 & 7.4.2	HC Personal attribute - Altruism – non-financial value-add.	RQ1
6.6.2 & 7.4.2	Identification of IM mediators & knowledge brokers – free reveal.	RQ1
6.6.3 & 7.4.2	SC value local relationship behaviour – Welsh Community Spirit.	RQ1
6.6.4 & 7.4.2	SC value local informal networks – rural hamlet level.	RQ1

7.5.8 New opportunities (supply & demand) – Productive HC-SC

Chapter Six mutual learning and cooperative interplay findings to answer RQ2 identified numerous HC, SC, SFC and IM analysis opportunities within the case study area and are summarised below in each section to answer RQs (Table 7.14).

Table 7.14 Summary of new opportunities - supply & demand – positive HC-SC

Section	Summary of new findings	RQs
6.8.1 & 7.4.1-7.4.4	HC-SC – case study area (IM analysis opportunities).	RQ1-3
6.8.2 & 7.4.1-7.4.4	SFC - local-authority level (IM analysis opportunities).	RQ1-3

7.5.9 New barriers (supply & demand) – Counterproductive HC-SC

Chapter Six detailed definition analysis identified negative and counterproductive human & social capital. These were discussed in potential intervention 2 (Section 7.4.2) and salient points are summarised below to answer RQs (Table 7.15).

Table 7.15 Summary of new barriers – supply & demand – negative HC-SC

Section	Summary of new findings	RQs
6.3.7	Hindrances to supply HC – counterproductive personal attributes.	RQ1
6.4.10	Hindrances to supply SC – counterproductive relationship behaviour.	RQ1
6.5.5	Hindrances to demand HC – counterproductive personal attributes.	RQ1
6.6.5	Hindrances to demand SC – counterproductive relationship behaviour.	RQ1

7.5.10 Summary of revised conceptual framework - Answers to RQs

In summary, there are multiple answers to the RQs from both the supply & demand analysis. A synthesised summary of the revised conceptual framework to answer the RQs is provided in following (Table 7.16).

Table 7.16 Summary table of answers to RQs in revised conceptual framework

RQs	Answer	Evidence Summary Tables
RQ1. What capital resources are required for NGA to be viable for rural communities and MBs to experience four-fold capital benefits?	Non-financial value-add of human & social capital, in both supply & demand ecosystems, **is** required to sit alongside shared financial capital (SFC) to reach final few. Currently, local authorities and commercial suppliers are not valuing HC & SC as CSFs to reach the final few.	Supply analysis – 7.3, 7.4, 7.5, 7.6 Demand – 7.7, 7.9 Supply & demand – 7.10, 7.11
RQ2. How can multiple stakeholders in both supply & demand ecosystems mutually learn & cooperate to resolve this complex rural digital divide?	New IM analysis at local-authority level to identify information & knowledge flow, mediators, knowledge brokers, hubs & OI, co-creation collaborative opportunities to reach final few. Enforced effects of COVID is new driver to reach final few.	Supply – 7.3. 7.4, 7.5, 7.6 Demand – 7.7, 7.8 Supply & demand – 7.10
RQ3. What new and innovative approaches can be utilised to manage & measure this process?	"First in Wales" initiatives at local authority level & value of NED/HVS conceptual framework to connect core assets of several stakeholders to reach final few.	Supply – 7.4, 7.6 Supply & demand – 7.10

7.5.11 New contributions – Innovation analysis (IM) to rural broadband

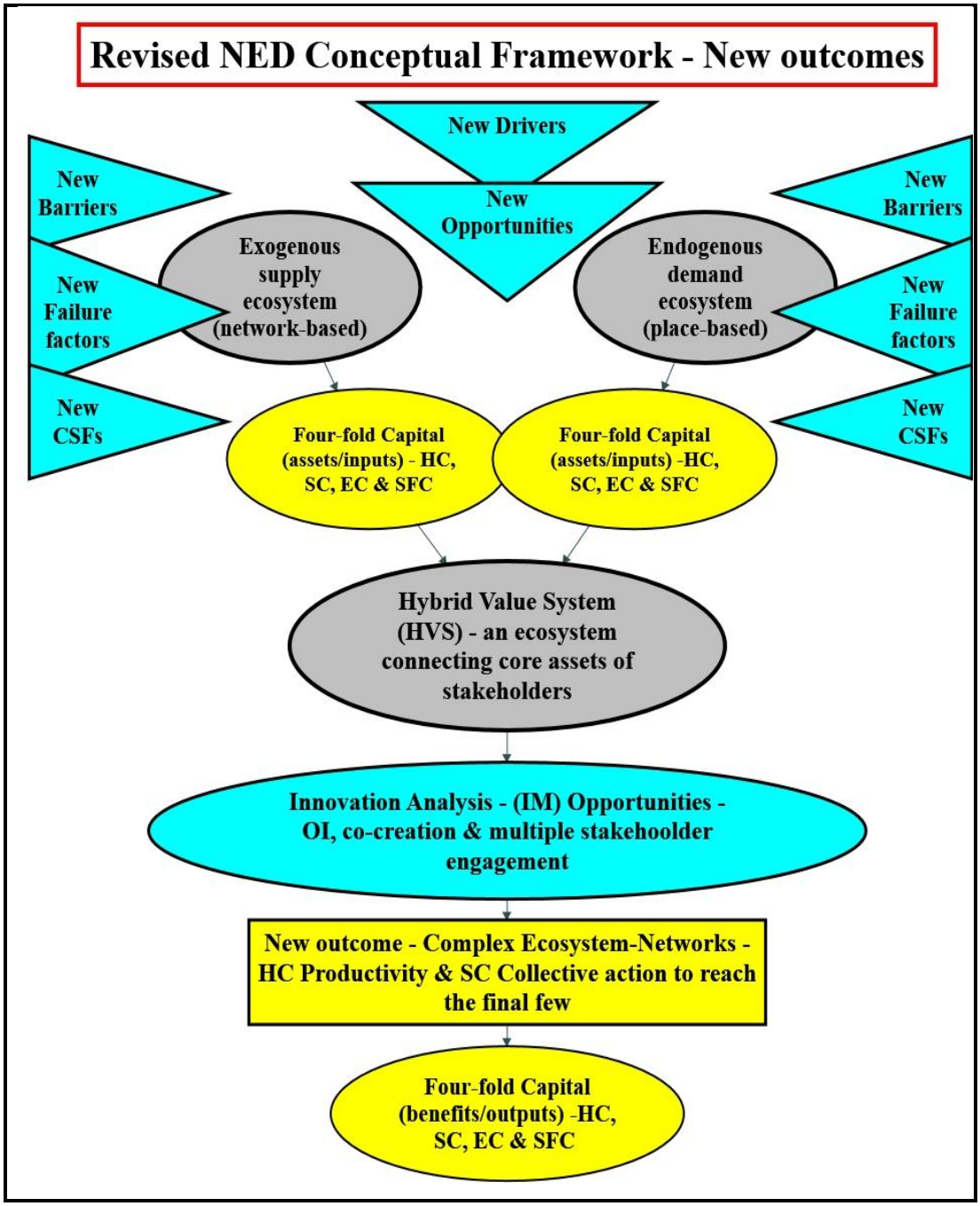
The introduction of innovation analysis (IM) opportunities to incorporate open innovation (internal/external networks), co-creation (users, LDCs) and multi-stakeholder engagement (across both ecosystems) has revealed multiple opportunities to reach the final few in Wales. The appropriability conundrum of who benefits from innovation can be resolved by appreciating the non-financial value-add of human & social capital. A new 21st-century paradigmatic change in thinking is required for all stakeholders to assess and value the four-fold capitals up front in the business model for a more holistic approach to problem area resolution.

7.5.12 New outcome – HC productivity & SC collective action

The novel mutual business (IM) Hybrid Value System (HVS) has proven to uncover rich and meaningful data to "connect the core assets of several stakeholders" (Section 6.9, Figure 6.26). The four-fold capital resources, particularly the non-financial human, social and environmental assets (inputs) contributes to the four-fold capital benefits (outputs) for rural community stakeholders (as evidenced in Section 5.8).

The new outcome for the conceptual framework is the complex ecosystem-networks and the positive HC productivity & SC collective action required to "get the job done" and reach the final few. The revised NED/HVS conceptual framework is summarised in (Figure 7.7).

Figure 7.7 Revised NED/HVS Conceptual Framework



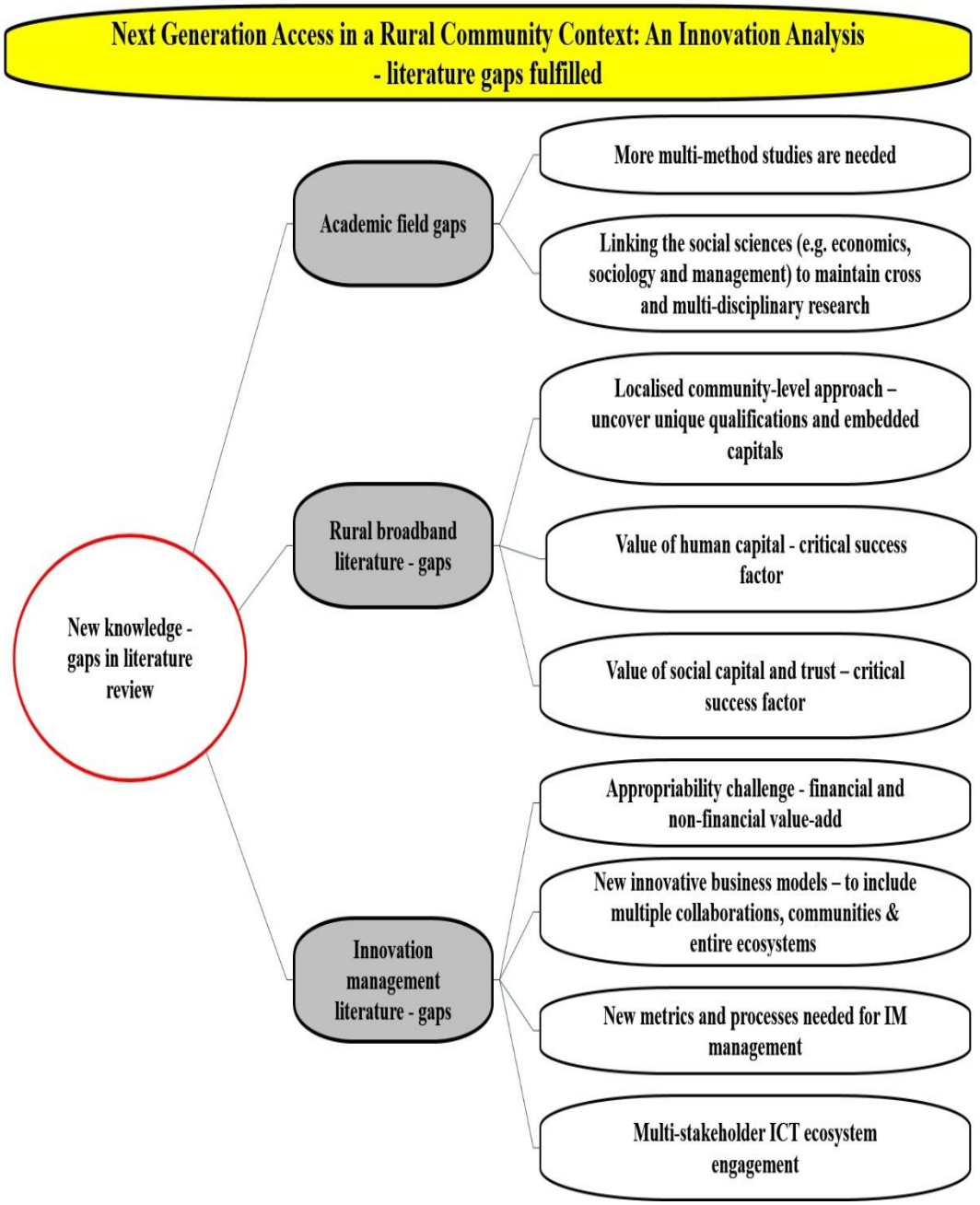
**CSFs (critical success factors), Human capital (HC), Social capital (SC), Environmental capital (EC), Shared financial capital (SFC).*

In summary, the NED/HVS conceptual framework has expanded to introduce the innovation (IM) analysis, the mapped evaluation of complex ecosystem-networks and new positive HC productivity & SC collective action to reach the final 95k. COVID19 has proven to be a new driver with opportunities to connect the final few and enhance the four-fold capital benefits when working from home (e.g. teleworking, reduced costs & travel).

7.6 Gaps in the literature fulfilled

The gaps in the literature review and relevant references are summarised in (Section 3.9, Table 3.14). Hence, they will not be repeated for this discussion. The following figure provides a summary map to review how this study has contributed new knowledge to the academic field, the rural broadband and IM literature (Figure 7.8).

Figure 7.8 New knowledge – gaps in literature review - fulfilled



7.6.1 The academic field – New knowledge

This research is a multi-disciplinary, multi-method in-depth intrinsic case study at the local community-level, thus fulfilling the gaps identified in the academic field, rural broadband and IM literature (Section 3.8). The intermarriage between the social sciences was equally required to maintain academic rigour (Section 3.9, Table 3.14). Thus, this research has achieved this goal by combining the NED economic growth model, for both exogenous supply and endogenous demand at the local level, and concepts from sociology resilience model (e.g. human agency, sense of place, and capital resources embedded in the community) within a local milieu (LM) geographical context (e.g. Pembrokeshire, South Wales). This research therefore has achieved these goals by contributing new knowledge within the academic field identified for this study (Section 3.2.4). The NED, resilience and place-based theoretical literature is summarised as a core concept in (Section 3.8.1). The core concept was applied to the potential intervention areas, which confirmed, extended and added new findings to the literature and conceptual framework (Section 7.4, Tables 7.1 – 7.4).

7.6.2 The rural broadband literature – New knowledge

This research sought to combine the gaps and core concepts identified in the literature into the conceptual framework (Section 3.8.8). The gaps in the literature called for a local community-level approach (unit of analysis) to uncover the unique qualifications and embedded capitals (Section 3.9, Table 3.14). The value of HC & SC were identified as CSFs and incorporated into the study to evaluate community-led initiatives (Section 3.9, Table 3.14). Hence, human & social capital are the theoretical underpinning of this research and the empirical evidence presented in (Chapter Five & Six) confirms that both non-financial capitals are invaluable assets to reach the final 95k. The rural broadband literature is summarised as a core concept in (Section 3.8.2). The core concept was applied to the potential intervention areas, which confirms, extended and adds new findings to the literature and conceptual framework (Section 7.4, Tables 7.1 – 7.4).

7.6.3 The innovation analysis (IM) literature – New knowledge

This research introduced new IM analysis and techniques to evaluate the complexities of providing a product (NGA) to a final few and hard to reach (market) at the local level (e.g. four-fold capital mutual business HVS approach). The introduction of the Hybrid Value System (HVS) allowed analysis of both supply and demand stakeholder's capital resources in one study (Section 3.8.8 & 6.9). This research has achieved this goal and the outcome is a new Complex Ecosystem Assessment Tool (CEAT) for stakeholders to assess and analyse the net-value of the human & social capital, both positive and negative, within their complex ecosystem-networks (Section 7.4.2). This new network visualisation tool helps to identify HC productivity & SC collective action opportunities, and any counterproductive hindrances to reach the final 95k.

The IM analysis (Section 3.7) identified the appropriability conundrum or "who profits" from open innovation (OI) and co-creation. New innovative business models are required for 21st-century thinking to include multiple collaborations, communities and entire ecosystems (Section 3.7.3). In addition, the development of new measurements and processes to manage innovation are required (Section 3.9, Table 3.14).

This research has identified multiple opportunities for stakeholders to appreciate the value of the non-financial capitals (e.g. HC & SC) and to create new partnerships and robust business models to capitalise on the abundant shared financial capital (SFC) available within the ecosystem (Section 7.4.1 & 7.4.2). The appropriability conundrum can be alleviated if governmental and commercial stakeholders' "value" the four-fold capitals "up front" in their business models and subsequent complex ecosystem-networks (Section 7.4.3 & 7.4.4). Although the non-financial value-add is evidenced within both ecosystems, data suggests that **it is not appreciated or valued** as a critical success factor (CSF) to reach the final 95k (Section 7.4.1). The focus of activity and decision-making apparently still remains on financial capital. Therefore, a new 21st-century paradigmatic change in thinking is required for all stakeholders but it is achievable if there is a concerted effort to do so. These suggestions and others are contained in the implications for key stakeholders (Chapter Eight).

For example, the examination of the Splits-Ville case study suggests that if the Local Authorities (Engagement Officers) and Openreach (Rural Engagement Officers) can work together with the local communities, then the allocation of financial resources could be maximised (Section 7.4.1 & 7.4.4). If the commercial suppliers and local government can harness the Welsh Community Spirit (e.g. friendliness & understanding between local people) as a valuable non-financial asset of social capital fertility (Section 3.6.4) then robust business models can be developed for investment and delivery of NGA products and services at both nation (macro) and local (micro) level (Section 7.4.3 & 7.4.4).

The IM analysis provided the impetus to search within the case study for information flows (OI & co-creation), the value of knowledge brokers (or gatekeepers) and product champions as CSFs (Section 6.8.1, Figure 6.23). Further innovation concepts like systems integration (supply & demand engagement), collaborative efforts for multi-stakeholder engagement, led to uncovering the value of people like "Carol" whose volunteer "non-financial value-add" is a CSF for ICT implementation (Ley et al., 2014 in Section 3.7.4.3). All of these factors have been captured within the complex ecosystem (Section 7.4.2), the final nation-level (Section 7.4.3) and local-level (Section 7.4.4) IM network analysis.

Finally, the eight-stage model analysis tool (Section 3.5.1.1, Table 3.9) created by Salemink and Strijker (2016), to understand the complexities for NED stakeholders in community-led initiatives was observed as being managed by the EOs (Section 5.4.3). If the PCC digital strategy is successful, then the eight-stage model is an effective tool to evaluate the success of "local authority-led" (top-down) versus community-led (bottom-up) initiatives. Regardless of who or how the eight-stage model is applied, the neo-endogenous (NED) relationships are CSFs to either approach. The IM analysis is summarised as a core concept in (Section 3.8.5). The core concept was applied to the potential intervention areas, which confirms, extends and adds new findings to the literature and conceptual framework (Section 7.4, Tables 7.1 - 7.5).

Answers to the research questions (RQs) and the new contributions to knowledge will be summarised in (Chapter Eight). The following section summarises the conclusions to the discussion.

7.7 Conclusion of Discussion

At the outset of this study, no local authority in Wales had taken a proactive local community approach to resolve the digital divide in the final few and hard to reach rural areas (Section 5.2). Previously, rural communities had to take proactive initiatives themselves and the results were detailed in (Section 3.5.1). This new approach taken by the Pembrokeshire County Council (PCC) has re-shaped some of this study's thinking. Instead of the pressure being placed on rural communities to organise themselves, the PCC local authority is the "first of its kind in Wales" (Section 5.4.2).

The "First in Wales" initiatives are exciting but are to be determined by the "glass in the ground" measurement and how the shared financial capital (SFC) is allocated. Regardless of how these initiatives are achieved, the non-financial value-add of human capital (HC) & social capital (SC) is evidenced throughout this study (Chapters Five, Six & Seven).

The purpose and findings of this research adds to these new initiatives by identifying four potential interventions areas for Splits-Ville case study area and NED stakeholders (Section 7.4). Nevertheless, how the NED stakeholders interact will determine the positive HC productivity & SC collective actions to reach the final few (Section 7.4.3 & 7.4.4). The conclusions to this study will be summarised in (Chapter Eight).

Chapter Eight: Conclusion

8.1 Introduction

The purpose of this multi-method exploratory research was to investigate how to resolve next generation access (NGA) supply and demand challenges for rural communities and microbusinesses (MBs) in "final few" and hard to reach rural areas (Section 1.1). The in-depth intrinsic case study in Pembrokeshire, South Wales, aimed to investigate new innovative approaches to resolve this complex multi-stakeholder problem area (Section 1.1).

Previous studies revealed superfast broadband (SFBB) enabled rural communities and MBs to experience the four-fold human, social, environmental and financial capital *benefits,* but not every rural area has access (Section 1.4). In recent years, a new innovative 21st century "mutual business" approach has emerged to engage the four-fold human (HC), social (SC), environmental (EC) and shared financial (SFC) capital *assets* to resolve supply and demand challenges in final few and hard to reach markets (Section 1.1).

This research has been undertaken with the understanding that entrepreneurial activity and MBs are considered vital to the rural economy (Section 1.3). The Rural Digital Economy Hub, a research-centre based in the UK, stated by working digitally in flexible and innovative ways rural businesses and communities can build on their human, social, environmental and financial capital to generate new wealth and social opportunities (Section 1.3). Thus, NGA access is required for rural communities and microbusinesses (MBs) to experience the four-fold capitals as assets and benefits (Section 1.4).

The research problem identified that there are discrepancies in take-up rates to stimulate investment in Wales (Section 1.5). The suggestion made by commercial suppliers is that more coordination is required to clarify business models, not only for investors, but for suppliers and NGA demand (take-up) in rural communities (Section 1.5). The Rural Gigabit Connectivity (RGC) full-fibre programme and Rural Connected Communities (RCC) 5G programme reveal that the market is changing but it is complex (Section 1.5). The government cannot cater to individual needs and

community-led initiatives are not always successful (Section 1.5). Prior research into the critical success factors (CSFs) of rural community-led initiatives identified the value of human & social capital, but more research is required through community engagement to identify local differences that contribute to the success or failure of investment (Section 1.5).

The research identified a need for more collaborative efforts and suggested the value of combining supply and demand stakeholders into a local community-led initiative (Section 1.6). Managing this type of innovation is difficult, particularly within complex multi-stakeholder ecosystems (Section 1.6) and an exploration of the innovation management (IM) literature, as a result of ICT innovation, revealed that ecosystems, networks, open innovation (OI), co-creation and multi-stakeholder engagement is compulsory for 21st-century business. Appropriability challenges, or "who benefits financially & non-financially" from innovation, remains to be reconciled in multi-stakeholder engagements suggesting that new approaches are required to manage and measure this process (Section 1.6).

The literature review therefore confirmed that rural communities and MBs have a demand for improved access to NGA services, but that it is not commercially viable for telecommunication suppliers to provide it in the final few and hard to reach rural areas (Section 1.2). Hence, there is a supply and demand challenge to overcome. This confirmed the need for this study to identify those activities and behaviours that would enable rural communities and MBs to access and exploit NGA services, particularly in relation to the incoming fourth industrial revolution, or Industry 4.0 (Section 1.2).

To state simply, this thesis investigated how to get an NGA (product) to a final few (market). This was achieved by combining rural broadband and IM literature concepts at the local community-level to introduce new thinking into this persistent problem area (Section 3.5 - 3.7).

The outbreak of COVID19 during this research hastened the need for rural connectivity (Section 1.1). For example, the reliance on videoconferencing became an essential requirement for rural economic and social engagement (Section 5.8.5). The beneficial environmental impact of increased digital connectivity was evidenced

during the reduction in travel during the lock-down, further confirming the value of reliable rural connectivity (Section 6.2).

The context of this research was Wales, due to the lack of rural broadband research in this nation as opposed to England or Scotland (Section 1.4). The regional and local community was Pembrokeshire, South Wales because it is one of three regions within Wales with the most remaining "white premises" (Section 2.1.3 & 2.1.4). The defining of rural communities, rural "capital" and rural ecosystems used for this study are explained in (Section 2.2 & 2.3).

The rural broadband and IM analysis is reviewed in (Sections 3.5, 3.6 & 3.7) and the conceptual framework combining the gaps in research is summarised in (Section 3.8). This study combined exogenous supply and endogenous demand, known as a neo-endogenous (NED) approach, at the local community-level using the mutual business "Hybrid Value System" (HVS) as an ecosystem connecting the core assets of several stakeholders. Therefore, NED/HVS is the framework selected to answer the research questions (RQs).

The exploratory in-depth intrinsic case study methodology identified to investigate the finesses of complex exogenous supply and endogenous demand ecosystems is summarised in (Section 4.6). The practical pragmatic philosophy underpinning this research resides in getting a product to a final few market and is the natural proclivity of this researcher (Section 4.2). Hence, the analysis of the nation-level (macro) context influencing the complex NED ecosystems (Chapter Five), and the local-level (micro) detailed analysis of human capital (HC) and social capital (SC) to reach the final few (Chapter Six) is the primary focus and outcome of this research.

To conclude, this research employs a neo-endogenous (NED) combined approach at the local community-level to investigate how to get NGA (product) to a final few (market) through a unique in-depth intrinsic case study in a final few and hard to reach rural area in Pembrokeshire, South Wales. The application and value of this study are discussed in (Chapter Seven) and summarised in this concluding chapter (Chapter Eight).

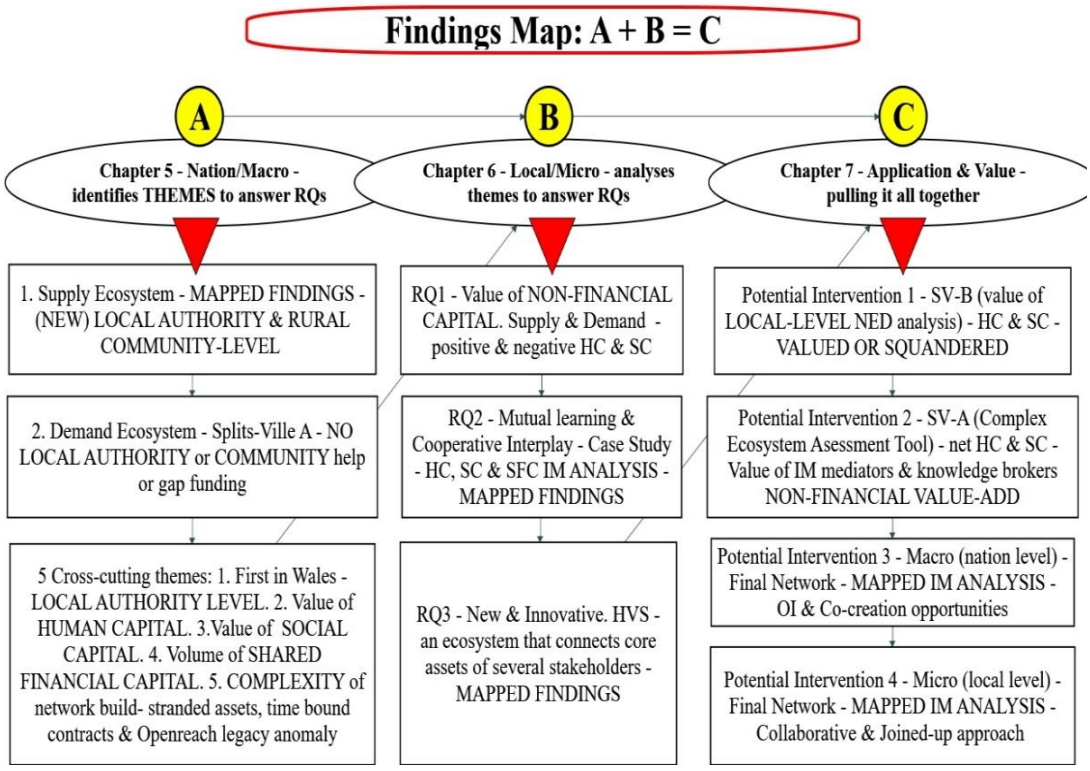
8.1.1 Chapter Overview

This chapter draws this research to a conclusion with a summary of significant findings (Section 8.2). The evidence provided in (Chapter Five, Six & Seven) to answer the RQs is summarised in (Section 8.3). The contributions to knowledge are recapped in (Section 8.4). The contributions and recommendations for practice are presented in (Section 8.5). The implications for key stakeholders are explained in (Section 8.6). The problems identified in this research are summarised in (Section 8.7). Limitations of this research and future recommendations are provided in (Section 8.8 & 8.9). A final conclusion to this novel in-depth case study is summarised in (Section 8.10).

8.2 Complexity of research - Summary of findings

A summarised figure to capture and illustrate the complexity of this research was presented in (Section 7.2.1, Figure 7.1) and re-stated below (Figure 8.1). This research was complex because it managed the analysis of two separate ecosystems with multiple stakeholders and four-fold capital analysis as inputs (assets) and outputs (benefits) (Section 3.8.8).

Figure 8.1 Summary of significant findings



Chapter Five (A) details the nation (macro-level) findings which resulted in *five cross cutting themes* (e.g. new local authority level, value of human capital, value of social capital, value of shared financial capital & complexities of network build). These themes are discussed in unexpected findings (Section 7.3.2). **Chapter Six (B)** details the local (micro-level) analysis of human & social capital and the IM analysis of connecting the core assets of several stakeholders within the case study area (6.8.1, 6.8.2 & 6.9). **Chapter Seven (C)** discusses the application and value of this research through four potential intervention areas (Section 7.4). The first two potential intervention areas examine the HC-SC interplay within the case study area (Splits-Ville A & B) and how human & social capital are not valued by local authorities or commercial suppliers as critical success factors (CSFs) to reach final 95k (Section 7.4.1 & 7.4.2). The final two potential intervention areas provide a mapped nation and local-level innovation (IM) analysis for open and co-creation opportunities to reach the final few (Section 7.4.3 – 7.4.4).

In summary, the significant findings are the local authority level to allocate funding and engage with the non-financial value-add of human & social capital within neo-endogenous (NED) ecosystems. The mapped analysis provides network visualisation to identify IM opportunities within both ecosystems to reach the final 95k. How local authorities and commercial suppliers value or squander the non-financial capital is yet to be determined.

8.3 Answers to research questions (RQs)

A synthesised overall summary to answer the RQs from the revised conceptual framework is found in (Section 7.5.10, Table 7.12). Nevertheless, the following section restates the answers to the RQs by referring to the evidence presented in the previous chapters (Chapters Five, Six & Seven). Notably, the exogenous supply findings are *network-based* whilst endogenous demand findings are *place-based.*

8.3.1 Capital resources – Four-fold capital assets & benefits (RQ1)

The first RQ asks what capital resources are required to support infrastructure to enable NGA to be viable for rural communities and microbusinesses (MBs) to experience the four-fold capital benefits? RQ1 has been answered in numerous ways through the value of both financial and non-financial capital (Section 6.11).

8.3.1.1 Supply ecosystem – Human, social capital & hindrances therein

The evidence presented in the "First in Wales" initiatives and the value of human capital (HC) & social capital (SC) exhibited within the Welsh Government, PCC local authority, Engagement Officers (EO) are summarised in (Section 5.2.5 & 5.4.5).

The exogenous supply "First in Wales" initiatives discovered in (Section 5.2.5 & 5.4.5) are driven by proactive, dynamic and enthusiastic leadership (Section 6.3). The non-financial value of supply human capital leadership, proactivity, people & soft skills, local champions and tacit knowledge (e.g. spectrum of human behaviour) are critical success factors (CSFs) for HC productivity to reach the final few (Sections 6.3.1 – 6.3.6). The hindrances to HC productivity are identified as lack of skills, lack of knowledge and counterproductive personal attributes (e.g. passivity) which can be used for mitigating obstructions to HC and reaching the final few (Section 6.3.7).

The non-financial value of supply social capital exhibited through different interpretations of trust (e.g. confidence, mutual respect, right environment & transparency) are summarised in (Section 6.4.2). The approaches to SC relationship behaviour towards each other is summarised in the quotation *"better to engage than enrage"* (Section 6.4.3). The non-financial value of SC relationship behaviour, such as the friendliness of the Welsh Community Spirit, contributes to HC productivity & SC collective action. The approaches to SC networks and working together to share information is summarised in (6.4.4). The joined-up approach for an IM centralised hub (single point of contact) and the effectiveness of IM mediators & knowledge brokers within the complex ecosystem-networks to maintain working together & sharing information are CSFs to HC productivity & SC collective action (Section 6.4.5 & 6.4.6). Conversely, the counterproductive barriers to SC collective action, such as lack of trust, lack of relationship behaviour and networks to work together and share information (Section 6.5.5) must be mitigated to reach the final few.

8.3.1.2 Demand ecosystem – Human, social capital & hindrances therein

The endogenous demand human capital findings, such as the value of local digital champions (LDCs), and the altruistic motivations that contribute to the local community and sense of place (Section 6.5.1 – 6.5.3) are valuable non-financial contributions and confirm/extend previous rural broadband studies (Section 3.5 & 7.3.1). The HC hard, soft skills and local tacit knowledge are valuable non-financial

contributions and should not be overlooked (Section 6.5.4). The barriers to HC productivity within rural communities are the lack of skills, lack of knowledge and counterproductive personal attributes (Section 6.5.2).

The value of demand social capital for collective action include trust, IM mediators & knowledge brokers similar to supply SC (Section 6.6.2). The non-financial value of the Welsh Community Spirit is equally confirmed and extended (Section 6.6.3). The richness of formal and informal SC networks are additional non-financial value-adds (Section 6.6.4). The hindrances to SC collective action within the demand ecosystem are distrust, counterproductive relationship behaviour and lack of networks to collaborate and share information (Section 6.6.5). These findings confirm, extend and contribute new knowledge to previous rural broadband studies (Section 3.5 & 3.6).

8.3.1.3 Shared financial capital (SFC) & environmental capital (EC)

The shared financial capital (SFC) is available and plentiful within the supply ecosystem (Section 5.11). How the exogenous supply and endogenous demand HC & SC is activated to capitalise on the abundant SFC within the ecosystem is to be determined (Section 6.8.1 & 6.8.2). Environmental capital (EC) is not a primary focus of this research but the outbreak of COVID19 confirms the assertions of a lower carbon footprint with the ability to work from home with videoconferencing (Section 5.8.8) which confirms previous rural broadband findings (Section 3.5). Health and surveillance concerns over 5G are still to be determined (Section 5.10.3) but full-fibre connectivity is now considered an essential requirement post-COVID19 (Section 6.2).

The fundamental answer to (RQ1) is the strongly evidenced non-financial value-add of human & social capital within both the exogenous supply (Section 5.2, 5.3, 5.4, 5.5 & 5.6) and endogenous demand ecosystems (Section 5.7 & 5.8). The summarised evidence for the nation-level (macro) findings in the complex ecosystems is found in (Section 5.11). The summarised evidence for the local-level (micro) analysis of capital contributions is found in (Section 6.7).

In conclusion, the unequivocal non-financial value-add of HC productivity & SC collective action, particularly at local authority-level, are CSFs to get the job done and reach the final few (Section 7.3.2.1, 7.3.2.2, 7.3.2.3 & 7.3.2.4). These non-financial

capitals, alongside the shared financial capital, are required to support infrastructure, thus answering (RQ1).

8.3.2. Mutually learn & cooperate (RQ2)

The second RQ asks how can multiple stakeholders in both supply & demand ecosystems mutually learn and cooperate to resolve this complex rural digital divide challenge? RQ2 has been answered in multiple ways.

Firstly, the exogenous supply HC & SC mutual learning and cooperative interplay are summarised (Section 6.8.1). For example, the “First in Wales” initiatives provide evidence that an IM centralised hub and “joined-up” approach provides a forum for mutual learning and cooperative interplay (Section 5.2.5). The centralised hubs incorporate IM mediators & knowledge brokers for barrier busting, conflict resolutions, disseminate knowledge and the ability to share best practice to support the proactive local authorities and inspire the less proactive local authorities (Section 5.2.5 & 5.4.5).

Secondly, the complexity of the full fibre network build is a key finding in this research (Section 5.4.1.3 & 5.5.1). However, opportunities for HC, SC, EC and SFC mutual learning and cooperative interplay are evidenced in (Section 5.10.2).

Thirdly, the supply ecosystem in Wales has plentiful SFC opportunities and the mutual learning and cooperative interplay is evidenced in (Section 6.8.2). For example, the £80m clawback clause allocation to reach the final few, the “Wall of Money” funding opportunities with both private and taxpayer investment, and the flexibility with the new Dynamic Purchasing System (DPS) are evidence of mutual learning and cooperative interplay (Section 6.8.2). How the stakeholders mutually learn and cooperate to capitalise on these interventions will depend upon the proactive HC leadership & SC behaviour towards the open innovation (OI) and co-creation opportunities available to them to resolve the final 95k (Section 7.4.3 & 7.4.4).

Finally, the endogenous demand ecosystem equally provides evidence on multi-stakeholder engagement, mutual learning and cooperative interplay (Section 5.4.2 & 5.4.3). The LDCs within Splits-Ville case study explained the frustrations of the enforced "do it yourself” (DIY) options (Section 5.8.1 & 5.8.5). However, the LDCs expressed relief when the PCC Engagement Officers (EOs) were introduced into the

pilot project area to act on their behalf (Section 5.8.5.4). The opportunity for mutual learning and cooperative interplay between the local authorities, commercial suppliers and rural communities is summarised in (Section 6.8.1 & 7.4.1 – 7.4.4).

Overall, there are multiple opportunities within both complex ecosystems for mutual learning and cooperative interplay (Section 6.8). The human, social capital, IM analysis (Section 6.8.1) and shared financial capital interactions (Section 6.8.2) provide an overall summary on how multiple stakeholders can engage to resolve the complex digital divide challenge thus answering (RQ2).

8.3.3 New & innovative approaches (RQ3)

The third RQ asks what new and innovative approaches can be utilised to manage and measure this process. RQ3 has been answered in multiple ways. The evidence presented by the "First in Wales" initiatives is one answer provided by the Welsh Government and PCC local authorities (Section 5.7). However, additional approaches have been identified and trialled in this research.

Firstly, the "Hybrid Value System" (HVS) as an ecosystem connecting the core assets of several stakeholders provides a new innovative approach to manage and measure this process (Section 6.9). The identification of the four-fold capital assets as resources in both complex ecosystems provided an assessment tool to manage and measure this process (summarised in revised conceptual framework Section 7.5).

Secondly, the results of the HVS, provided the evidence required to identify the productive value of HC & SC, but also the counterproductive hindrances therein (Section 6.9). Both positive and negative effects are required to understand the HC productivity & SC collective action within each complex ecosystem to manage and measure results. The creation of the Complex Ecosystem Assessment Tool (CEAT) was derived as a result of the HVS (Section 7.4.2).

Thirdly, the HVS is part of the mutual business four-fold capital approach and a more holistic 21st-century method to business ecosystem engagement (Section 3.7.3). Henceforth, the *four-fold capital benefits* (outputs) as a result of SFBB (product) implementation into a remote rural area (market) can be married to the *four-fold capital assets* (inputs) advocated by the four-fold capital mutual business model (Section 3.8.8.3). The identification of human, social, environmental and shared

financial capital and the use of the HVS, and CEAT, to identify and analyse this process answers (RQ3).

Finally, open innovation (OI) and co-creation IM opportunities are abundant within both the macro nation-level (Section 5.11) and micro local-level contexts (Section 6.8.1 & 6.8.2). The final network IM analysis can be a new visualisation approach to resolving the digital divide (Section 7.4.1 – 7.4.5), thus contributing to answering (RQ3).

8.4 Contributions to knowledge - Summary

This research adds new knowledge to the academic field, rural broadband and IM literature (Sections 7.3.1) and summarised through the following contributions. This study contributes theoretically by confirming, extending and adding new knowledge to human & social capital theory and IM analysis (Section 7.4 - 7.6). This research has contributed new evidence of HC productivity & SC collective action (Section 7.5.12) as non-financial critical success factors (CSFs) in local-level complex ecosystem-network IM analysis to reach the final few (Section 7.3.2.2 & 7.3.2.3).

8.4.1 Non-financial human & social capital - Valued or squandered (RQ1)

The non-financial value-add of both supply (network based) and demand (place-based) human & social capital has been evidenced throughout this thesis (Chapters Five, Six & Seven). New contributions of both human & social capital were evidenced in (Chapter Six) and discussed in unexpected findings (Section 7.3.2.2 & 7.3.2.3). How these capitals can not only be valued but also squandered was presented in Splits-Ville B (SV-B) potential intervention area (Section 7.4.1) and Splits-Ville A (SV-A) net-effect of HC & SC within complex NED ecosystems (Section 7.4.2).

8.4.2 The identification of net HC-SC interplay (RQ1, 2 & 3)

The identification of net HC-SC interplay is a new contribution to knowledge and not previously discussed in rural broadband or IM literature (Section 7.4.2). Moreover, the hindrances to HC productivity & SC collective action within complex ecosystem networks is a new contribution to knowledge for both rural broadband and IM analysis (Section 7.5.10). The creation of the Complex Ecosystem Assessment Tool (CEAT) contributes a new innovative approach to manage and measure this process (Section 7.4.2).

8.4.3 IM analysis to rural broadband literature (RQ2)

A primary new contribution to knowledge is the extension of IM analysis to rural broadband literature (Section 7.5.11). Notwithstanding the use of the HVS as an innovation (IM) analysis tool, but the identification of IM mediators, knowledge brokers, centralised hubs and the value of mapping complex-ecosystem networks for analysis (Section 7.6.3).

8.4.3.1 The value of IM analysis - Mediators, knowledge brokers & hubs

The identification of IM mediators, knowledge brokers and centralised hubs to facilitate conflict resolution and informational knowledge flow throughout the complex ecosystem-networks (6.8.1) is new knowledge to rural broadband analysis (Section 7.5.11).

8.4.3.2 The value of IM analysis – Creation of network visualisation tools

The mapped complex-ecosystem analysis allowed the creation of network visualisation tools (Section 7.4.2 – 7.4.5). The mapped network analysis on how to resolve the digital divide in Wales through engagement at the local authority level contributes new knowledge to bridging the digital divide in Wales (Section 6.8.1, 6.8.2, 6.9 & 7.5).

8.4.4 NED/HVS conceptual framework – Connecting core assets (RQ3)

The conceptual framework contributes new knowledge by introducing a neo-endogenous supply and demand (NED) local community approach using the Hybrid Value System (HVS) as an ecosystem that relies on connecting the core assets of several stakeholders (Section 6.9 & 7.4). The interweaving of the rural broadband and IM literature to produce a multi-disciplinary study to maintain academic rigour was achieved in the revised conceptual framework (Section 7.5). The multiplicity and complexity of findings is attributed to the NED/HVS framework analysis (Section 7.6.1).

8.4.5 Summary of contributions to knowledge

To conclude, the contributions to knowledge are encapsulated in the revised conceptual framework (Section 7.5) and summarised throughout the literature discussions in the four potential intervention areas (Sections 7.4.1 - 7.4.4, Tables 7.1 - 7.4). The NED/HVS conceptual framework being the overall analysis tool to manage

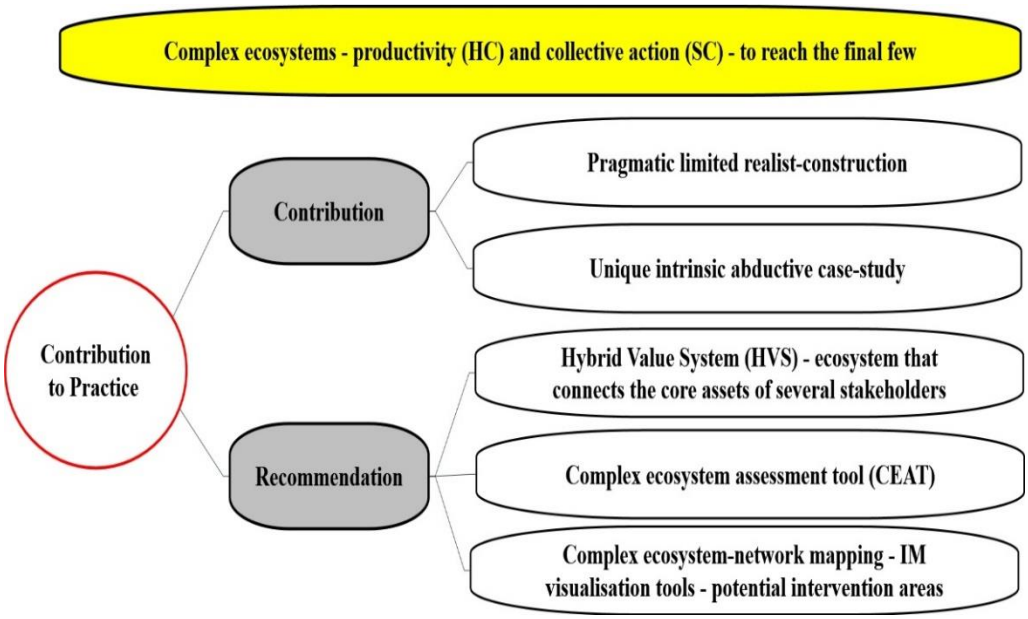
and investigate the complexity and capture the multiplicity of findings of four-fold capitals within two ecosystems and engaging multiple stakeholders (Section 7.5.12, Figure 7.7). This study has filled gaps identified in the literature review that address previous lack of knowledge of the NED supply and demand local community approach and how the IM hybrid value system (HVS) can be utilised to galvanise connectivity for the final few and hard to reach rural communities. This is a contribution of new knowledge to the digital divide debate in the UK (Section 7.6).

At the outset of this study, no local authority in Wales had taken a proactive local community approach to reach the final few (Section 7.7). To identify and value and not lose or squander the non-financial value-add of human & social capital is a core finding of this research. The IM analysis tools to aid in mapping the complex-ecosystem networks supplement this core finding and contributes new knowledge to the academic field, rural broadband and IM literature (Section 7.6).

8.5 Contributions & recommendations for practice

This researcher's contribution to knowledge is determined by the purpose and findings (Section 8.1 & 8.2), answers to RQs (Section 8.3) and contributions to knowledge (Section 8.4). The following diagram summarises the contributions and recommendations for practice (Figure 8.2) which are further developed throughout this section.

Figure 8.2 Contributions & recommendations to practice



Contributions to practice

This study provides two contributions to practice. One is a pragmatic approach, and the other is a flexible and unique abductive case study to analyse new opportunities to bridge the digital divide.

8.5.1 Pragmatic limited realist-constructionist contribution

The definition of pragmatism is that concepts are only relevant where they support action; it considers research with a problem and aims to contribute practical solutions that inform future practices (Section 4.3.2). The limited realist onto-epistemological approach seeks to develop an account that is credible and potentially transferrable; conclusions will always be tentative, using *a priori* themes informed by theory or evaluation criteria (Section 4.3.1, Table 4.1). Pragmatism believes ideas should be clear and knowledge should have practical output (Section 4.3.2). Thus, the practical output of valuing human & social capital (theoretical *a priori* themes) which evolved into a "Complex Ecosystem Assessment Tool" (CEAT) promotes action and is a practical solution that informs future practice. The philosophical inquiry of what is meant by these concepts, models and terminology is captured in the local-level analysis of HC productivity & SC collective action (Section 4.3.1 & summarised in Chapter Six) with the explicit goal of reaching the final few. Henceforth, the limited realist-constructivist contributions of this research has been fulfilled.

8.5.2 Intrinsic case-oriented abduction contribution

Recent qualitative business management research suggested a resurgence of more flexible and abductive approaches to case study analysis and recommend Stake's approach versus a more "positivist" approach advocated by Yin and Eisenhardt (Section 4.5.2). The abductive approach cherishes flexibility of research design and views re-direction of the case study as a source of theoretical insight and learning (Section 4.5.2). Hence, the divergence records (Section 4.10) as a result of changes to the original conceptual framework, allowed for the inclusion of a new "First in Wales" initiative (Section 5.2). Therefore, the application of human & social capital adopted a new innovative process (Section 4.10 & subsequent findings). Nevertheless, to improve credibility and validity this research followed Yin's case study protocols (Appendix G & H) whilst allowing for the flexibility in the research design to capture

the intrinsic changes to the case study area. Thus, weaving both approaches into one (e.g. flexible & positivist).

Recommendations for practice

This study provides three recommendations for practice. The research contributes practically with the creation of the following new assessment tools:

8.5.3 NED & Hybrid Value System (HVS) – Managing complexity

The new NED/HVS conceptual framework contributes to an open innovation systems approach by combining neo-endogenous supply and demand ecosystems (Section 3.7 & 7.4). The HVS was introduced by the mutual business four-fold capital approach and successfully trialled within this thesis (Section 6.9). Managing two separate ecosystems with multiple stakeholders is complex and the NED/HVS conceptual framework held the complexity together for data collection and analysis. The revised conceptual framework for complex ecosystems is HC productivity & SC collective action to "get the job done" and reach the final few (Section 7.5). Hence, the NED/HVS conceptual framework approach contributes new practice in rural broadband and IM research (Section 7.6).

8.5.4 Complex Ecosystem Assessment Tool (CEAT) – Net HC-SC analysis

The Complex Ecosystem Assessment Tool (CEAT) identifies the positive (productive) and negative (counterproductive hindrances) within a complex ecosystem-network which either contributes to HC productivity & SC collective action or obstructs it (Section 7.2.3). It was this tool that enabled the new understanding that these non-financial values can be lost, as well as valued, when utilising the Hybrid-Value System (HVS). The CEAT is a new practical tool for net HC-SC analysis.

8.5.5 Network visualisation tools – Final IM analysis

Final IM network analysis (nation & local-level) as a practical visualisation tool to map complex ecosystems and identify potential intervention areas for open innovation (OI) and co-creation opportunities and challenges (Section 7.4.3 & 7.4.4). In addition, the reflective network visualisation tool to identify IM centralised network hubs, mediators & knowledge brokers is a helpful assessment to understand information and knowledge flow within a defined ecosystem-network (Section 7.4.5).

In summary, the contributions to practice include the pragmatic approach to a unique intrinsic case study. The recommendations to practice include the value of IM analysis and the resulting conceptual framework and network visualisation tools (Sections 6.8.1, 6.8.2, 6.9, 7.4.3 – 7.4.5 & 7.5).

8.6 Implications for policy & practice - Key stakeholders

The implications of this study were signposted during the investigation of the case. The outcome of this study suggests that the value of human & social capital should be considered "up front" in each complex ecosystem-network alongside shared financial capital. Environmental capital was not a primary focus, but the four-fold capitals are symbiotic and all four should be considered "up front" in the business model to ensure a holistic and well-rounded approach to capital resource management in the 21st-century (Section 3.7). Industry 4.0 and the great de-urbanisation may become an accelerated reality post-COVID19 (Section 5.4.2, 5.8.5 & 5.9). Thus, the implications of these findings can aid the acceleration of HC productivity & SC collective action towards enabling NGA access for rural communities.

8.6.1 Beneficiaries of research

The beneficiaries of this research are all the key stakeholders within both exogenous supply (e.g. governmental & commercial suppliers) and endogenous demand ecosystems (e.g. local digital champions (LDCs), rural microbusinesses (MBs), residents & Citizen Service Organisations (CSOs). The UK Government benefits because they have reached their goal and connected the countryside with a mix of private and taxpayer investment funding, thus providing the four-fold capital benefits to rural areas evidenced in previous studies (Section 2.2.5 & 2.4). The Welsh Government in turn has achieved their respective goals whilst enabling local authorities to become an IM centralised hub and focal point for allocation of funds, conflict resolution, communication, HC productivity & SC collective action (Section 6.8.1 & 7.4.3). The Local Authority benefits from the recognition that within the rural communities lies a rich and vast amount of financial and non-financial capital resources waiting to be engaged or supported for HC productivity & SC collective action (Section 6.8.1 & 7.4.4). The commercial suppliers benefit because both ecosystems are working together to resolve the complexities of full-fibre network

build, and hopefully, to restore the negative brand reputation accumulated over the years (Section 6.8.2, 7.4.1, 7.4.3 & 7.4.4).

Finally, the true beneficiaries of this research are the final few and hard to reach rural communities and MBs who have struggled for years with less than adequate services and reduced productivity (Section 5.8.1, 5.8.5 & 5.8.7). The anticipated HC productivity & SC collective action of an IM "joined up" proactive and collaborative governmental and commercial suppliers' approach (Section 7.4.3 & 7.4.4) will provide them with NGA access and experience the four-fold capital benefits (Section 1.5, 2.2.5 & 5.8.3). Conversely, both ecosystems benefit by identifying the counterproductive hindrances to HC productivity & SC collective action (e.g. less authoritarian leadership, bureaucracy & passivity) in reaching the final few and can take necessary and pre-cautionary steps to identify and mitigate these challenges (Section 6.9).

8.6.2 New 21st-century paradigmatic thinking – Four-fold capitals

A positive and productive human, social, environmental and financial capital is in every nation, region, community and individual stakeholders' interest for growth and development (Section 3.2.4). It is not in any stakeholders' interest for human, social, environmental or financial capital to decline. Hence, regional economic growth models that stimulate investment in both HC & SC are warranted (Section 3.2.4). Terluin (2003) summarised the mixed endogenous/exogenous (or NED) rural economic growth model by combining territorial innovation and local milieu (placed-based) theory with the diffusion of innovation (Section 3.2.4.1, Table 3.6).

Furthermore, Lin (2002) provided a history of capital by comparing classical economic theories (Section 3.6.6). For example, Marxist views on capital (e.g. surplus profits made by labour) but argues the capitalist elite are subjugating the masses for personal profit (hence wealth is imbalanced) versus the neo-classical Human Capital Theory (HCT) (e.g. individuals are not subjugated & are free to develop human capital to provide value to themselves). However, Salemink et al. (2017a) argue the classical models overlook two essential factors, citing Capello (2011) regional economic growth theories and Castells (2010) network theory (Section 3.6.6).

To restate from the literature review, Salemink et al. (2017a) argue that a contemporary approach to regional development must involve the complexities of

rural communities with various stakeholders and network actors, whereby trust is an asset to reduce costs and facilitate the knowledge economy (Section 3.6.4). Lin (2002) defined capital as *"investment of resources with expected returns in the marketplace"* (Section 3.6.6). Flora (2016) defined capital as *"resources capable of producing other resources*" and identified seven capitals or assets relevant for rural communities to exercise (e.g. built, cultural, financial, human, natural, political & social capital) (Section 2.2.3). Thus, investment in HC productivity & SC collective action has expected returns in the marketplace.

The mutual business or four-fold capital approach introduced in this thesis can provide a "middle ground" between the classical Marxist (e.g. more equitable distribution of capital) and Capitalist (e.g. freedom of individuals to create) viewpoints (Section 3.6.6). The four-fold capital approach values both financial and non-financial capital within a business ecosystem (Section 2.2.4. 2.2.5, 3.6.7, 3.7.1 & 3.7.4). Thus, the NED conceptual framework, of combining both supply and demand stakeholders, through the HVS has implications for each stakeholder within that ecosystem (Section 3.8.8).

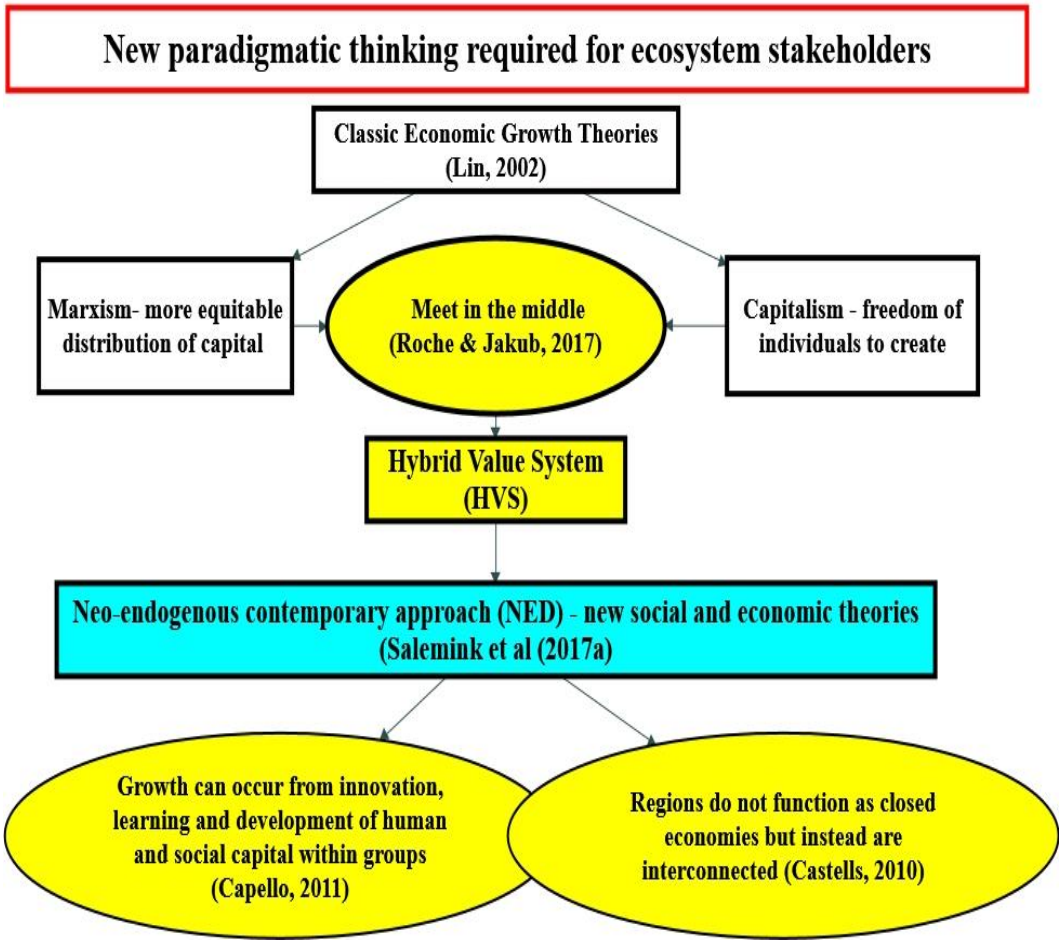
To clarify this proposition, the definition for hybrid is something that is a *combination of two different things*, so it has *qualities relating to both* of them. Value is defined as the amount of money that something is worth; the beliefs that people have about what is right, wrong and *most important in life*, business and so forth which *control their behaviour*. System is defined as a particular set of actions for doing something; a group of organisations that *work together for a particular purpose* or have similar activities.

Henceforth, the HVS can be characterised as an ecosystem that connects the core assets of several stakeholders which is a valuable engagement for all stakeholders (Section 6.9). The mutual business HVS can be used to bridge (combine) the two opposing philosophical viewpoints (qualities relating to both) into a "meet in the middle" proposition (what is most important in life to control behaviour & work together for particular purpose). However, this proposition is contingent upon the willingness of stakeholders in both ecosystems, to adapt to a new way of thinking (or paradigm) that is equitable for all stakeholders to reach the final few (Section 3.6.6, 4.2 & 7.4).

If governmental bodies focus on financial capital only, then they fail to capitalise on the rich non-financial human & social capital existing within both ecosystems (Section 7.4.1 – 7.4.4). If commercial suppliers maintain the Friedman mantra that the sole purpose of business is to provide profit for shareholders (Section 3.7.1) then 21st-century open innovation (OI), and co-creation opportunities, for both financial and non-financial value-add, will be lost or squandered within these complex ecosystems (Section 7.4.1 - 7.4.4). Hence, if a new holistic and well-rounded 21st-century thinking can inspire stakeholders "up front" in the business model, then there is hope to "meet in the middle" and value the four-fold capital resources as both inputs (assets) and outputs (benefits) for all stakeholders (and not shareholders-only) (Section 3.7.3.1).

The following (Figure 8.3) summarises the contemporary NED economic and social growth model encapsulated by the mutual business approach by valuing four-fold capitals "upfront" versus profit-only financial thinking (Section 3.6.6).

Figure 8.3 New 21st-century paradigmatic thinking required for stakeholders



In summary, the increasing hostility between the "left" (e.g. socialist tendencies) and "right" (e.g. capitalist tendencies) in political discourse can be reduced and deflated with a new approach to problem area resolution. A "new paradigmatic" attitude and mindset change towards a combined approach, contributes to a more accountable, equitable and holistic way forward for both economic and philosophical viewpoints.

8.6.3 Complex ecosystem-network analysis

Academics engaging in multi-disciplinary studies by understanding complex ecosystems and the abundant capital resources therein, can uncover deeper richness by using a complex ecosystem-network analysis approach. Network theory was not the original focus of this research, but future research could benefit from more involved and thorough network analysis. For example, the empowerment of proactive leadership or how to mitigate the counterproductive hindrances to HC productivity & SC collective action and so forth.

In summary, the implications for government, commercial suppliers, rural stakeholders and further academic research is evident. The understanding of complex ecosystem-networks, how they interact with a neo-endogenous (NED) engagement and a mutual business HVS approach can provide more holistic thinking for 21st-century open innovation and co-creation opportunities and challenges.

8.7 Problems arising during research

The challenge of this research was the introduction of the EOs into the case study area (December 2019). It is not deemed as a problem per se, but the initial analysis to develop a demand intervention through an NGA awareness training and Thrive Self-Assessment Tool was modified as a result (Appendix N). This initiative changed the outcome of the revised conceptual framework (Section 7.5) and subsequent research approach and instrument design (Section 4.10), but the accumulated findings are hopeful. If the PCC local authority strategy is successful, then it will be a template for other local authorities to follow. If it is delayed because of contract negotiations, labour shortages or time constraints, then the onus could return to the rural communities to act (Section 5.8.5).

8.8 Limitations of research

The limitations of this intrinsic case study is that it is a snapshot in time and a geographically bound location. The fast-moving telecommunications market and the post-COVID19 landscape are yet to be determined. The geographical context is regional, and Wales is a small country. The networks and relationships are more accessible within a smaller context versus a nation-state for example. Nevertheless, the case study reflects a "final few and hard to reach" rural area (market), and the mutual business HVS approach can be used universally for generalisability.

Additional limitations include the scope of the key stakeholders identified in the ecosystems. Ideally, if time permitted, more stakeholders could have been interviewed to saturate results, but as this research was time constrained, individuals were selected as the best representatives for their knowledge base. More interviews would have allowed for improved representation and validation. Nonetheless, this research provides a snapshot for developing NED research at the local community-level and can be considered a starting point for further research using the complex ecosystem-network assessment tools.

Furthermore, cultural and political capital were not included in this research but identified in the Community Capital Framework (Appendix M). Ideally, all seven capitals could be considered, but the focus of this research was on a pragmatic approach to business management problem area resolution (e.g. product to final few market) and thus deemed outside of the scope of this analysis.

8.9 Future research recommendations

Future research recommendations inspire a variety of opportunities. For example, network analysis was not the primary focus, but after the EOs and the outcome of interviews, this became more apparent. Network Theory therefore could be explored further to uncover additional CSFs and barriers therein.

The Pembrokeshire County Council (PCC) Digital Engagement Strategy would make an interesting case study post-completion to determine the success, or failure factors of this initiative. The hope of this researcher is that the initiative will be successful because the rural communities responded positively to the local authority

approach (Section 5.4.3 & 5.8.5). However, it is a work in progress and the "glass in the ground" will determine the success or failure of this "First in Wales" initiative.

As mentioned in the previous section, the Community Capital Framework (Appendix M) is a useful tool for evaluating all seven capital resources and assets within a rural community. Cultural and political capital were outside the scope of this research but could provide a more holistic evaluation for future research. The NGA demand awareness and Thrive Self-Assessment originally planned for this research was to interview and understand rural communities' aspirations and digital skill levels to maximise and exploit NGA access (Appendix N). The Cantril adapted NGA Self-Assessment could be a useful tool to understand and measure rural community interest of MBs, residents and SMEs (Appendix N).

In summary, this research was limited by time and scope of the key stakeholder analysis and by providing a snapshot of NED research at the local level. Future research can expand on complex ecosystem-network engagement through improved network theory and more in-depth rural community capital analysis. Nonetheless, this research has made multiple theoretical and practical contributions to knowledge (Section 7.5, 7.6, 8.4 & 8.5).

8.10 Conclusion

The goal of this research was to investigate how neo-endogenous (NED) stakeholders at the local community level can enable NGA (product) to reach a final few (market). The outcome of this research is how to analyse complex ecosystems for human capital productivity & social capital collective action to reach the final 95k and identify and mitigate the counterproductive hindrances therein (Section 7.7). The NED conceptual framework by utilising the Hybrid Value System (HVS) provides the ecosystem analysis to identify and connect the core assets of multiple stakeholders (Section 6.9).

Rural microbusinesses (MBs) interviewed in this study confirmed previous research that SFBB allows them to experience the four-fold capital benefits (Section 2.2.5 & 5.8.3), but the NGA supply challenge remains (Section 5.11). Post-COVID19, full fibre connectivity to support working from home and Industry 4.0 opportunities for rural capital growth is now considered an essential requirement (Section 5.8.7, 5.8.8 & 5.9).

The challenges to NGA supply and demand centre around the complexities of the network build and the mutual learning and cooperative interplay amongst the ecosystems (Section 5.11 & 6.8.1). The value of human capital productivity & social capital collective action are critical success factors (CSFs) to reaching the final few (Section 6.3 – 6.6). Conversely, the counterproductive hindrances to HC productivity & SC collective action must be mitigated for the goal to be reached (Section 6.7). Thus, the net HC-SC assessment is a non-financial value-add to reach the final few (Section 7.4.2).

The opportunities for open innovation (OI) and co-creation collaborations within both ecosystems is evidenced in the nation-level (Section 7.4.3) and local-level IM network analysis (Section 7.4.4). Nevertheless, how the stakeholders decide to engage, or not, will be the litmus test for successfully resolving the digital divide challenge. The mutual business HVS approach and new paradigmatic 21st-century thinking can aid in this step-change to capitalise on a more holistic and well-rounded approach to problem resolution by engaging all four capitals as assets and benefits (Section 8.6.2, Figure 8.3).

To conclude, as Roche & Jakub (2017) stated *"the true value of a business ecosystem is not only in the strength of its individual stakeholders but the strength of the links connecting them"* (p. 141). It is the hope of this researcher that the "middle ground" approach, uncovered by this research, can be utilised to bridge the digital divide and allow rural communities and microbusinesses (MBs) to experience the four-fold capital benefits NGA access can provide.

Appendices

Appendix A – Definitions

Table A1. Definitions & technical terms

Term	Definition	Resource
Access network	The part of the network that connects directly to customers from the local telephone exchange.	(Ofcom, n.d)
Active Optical Network (AON)	The AON arrangement is a point-to-point structure (PTP), meaning that each user has his own dedicated fiber optical line terminated on an optical concentrator. In an active optical system, environmentally electrical switching equipment are deployed, such as a router or a switch aggregator, to manage signal distribution and route data to proper places. The following figure show an AON system	(Fiber Optic Network Products, 2015)
Aggregation Node	Connects high-capacity spine to distribution cables	(Openreach, 2018)
Asymmetric Digital Subscriber Line (ADSL)	ADSL (Asymmetric Digital Subscriber Line): A technology used for sending data quickly over a conventional copper telephone line. It is used in current Internet services with download speeds up to 24Mbit/s.	(Ofcom, n.d)
Backbone	Just like the human backbone carries signals to many smaller nerves in the body, a network backbone carries data to smaller lines of transmission. A local backbone refers to the main network lines that connect several local area networks (LANs) together. The result is a wide area network (WAN) linked by a backbone connection. The Internet, which is the ultimate wide area network, relies on a backbone to carry data over long distances. The Internet backbone consists of several ultra-high bandwidth connections that link together many different nodes around the world. These nodes route incoming data to smaller networks in the local region. The fewer "hops" your data needs to make before reaching the backbone, the faster it will get sent to the destination. This is why many Web hosts and ISPs have direct connections to the Internet backbone.	(Christensson, 2006a)
Backhaul	The middle of the network, this is a high-capacity line which links the core network with local exchanges. This is the infrastructure beyond the local exchange	(Ofcom, n.d)

Bit or byte – short for binary digit	The smallest unit of measurement used to quantify computer data. The terms "bits" and "bytes" are often confused and are even used interchangeably since they sound similar and are both abbreviated with the letter "B." However, when written correctly, bits are abbreviated with a lowercase "b," while bytes are abbreviated with a capital "B."	(Christensson, 2019)
Broadband (basic)	Defined in the UK as speeds up to 2Mbps	(Hutton & Baker, 2018)
Central Office (CO)	A central office, in telecommunications, is a building to which subscriber home and business lines are connected on a local loop. This office has telephone switches to switch calls locally or to a long-distance carrier office. This term is also known as end office or public exchange.	(Technopedia, 2012)
Cloud Computing	Cloud computing refers to applications and services offered over the Internet. These services are offered from data centres all over the world, which collectively are referred to as the "cloud." This metaphor represents the intangible, yet universal nature of the Internet.	(Christensson, 2009)
Connectorised Block	Multi-port block terminates network outside premises	(Openreach, 2018)
Connectorised Frame	Terminates spine cables for FTTP and POP fiber	(Openreach, 2018)
Core network	The backbone of a communications network, which carries different services such as voice or data.	(Ofcom, n.d)
Digital Divide	The term digital divide refers to “the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to both their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities”.	(OECD, 2006)
Digital Subscriber Line (DSL)	A communications medium used to transfer digital signals over standard telephone lines.	(Christensson, 2014a)
Distribution Point	A point within a network where the cable or fibre terminates. This point provides a point of entry for engineers to terminate or test the network.	(Webopedia, n.d-a)
DSLAM	Stands for "Digital Subscriber Line Access Multiplexer." A DSLAM is a device used by Internet Service Providers (ISPs) to route incoming DSL connections to the Internet. Since a "multiplexer" combines multiple signals into one, a DSLAM combines a group of subscribers' connections into one aggregate Internet connection.	(Christensson, 2006b)
Duct	Existing trenches and pipes which hold copper and fibre lines.	(Ofcom, n.d)

Ethernet	Ethernet is the standard way to connect computers on a network over a wired connection. It provides a simple interface and for connecting multiple devices, such computers, routers, and switches. With a single router and a few Ethernet cables, you can create a LAN, which allows all connected devices to communicate with each other. NOTE: Ethernet is also known by its technical name, "IEEE 802.3."	(Christensson, 2014b)
Exchange	A building which houses electronic equipment that connects telephone calls. Backhaul links from a content provider are terminated here to connect access links to end users.	(Ofcom, n.d)
Fibre Optic Cables/Networks	A high-speed data transmission medium. It contains tiny glass or plastic filaments that carry light beams. Digital data is transmitted through the cable via rapid pulses of light. The receiving end of a fiber optic transmission translates the light pulses into binary values, which can be read by a computer.	(Christensson, 2014c)
Fibre-to-the-cabinet (FTTC)	An access network structure in which the optical fibre extends from the exchange to the cabinet. The street cabinet is usually located only a few hundred metres from the subscriber's premises. The remaining part of the access network from the cabinet to the customer is usually copper wire but could use another technology, such as wireless.	(Ofcom, n.d)
Fibre-to-the-home (FTTH/FTTP)	An access network structure in which the optical fibre runs from the local exchange to the end user's living or office space.	(Ofcom, n.d)
Fifth Generation Wireless (5G)	5G is the fifth generation of cellular data technology. It succeeds 4G and related technologies, including LTE. The first 5G cellular networks were constructed in 2018, while 5G devices became widespread in 2019 and 2020. 5G vs 4G Benefits of 5G include faster speeds, low latency, and greater capacity. The theoretical maximum data transfer rate of 5G is 20 Gbps (2.5 gigabytes per second). That is 20x faster than LTE-Advanced, which has a peak download speed of 1,000 Mbps. 5G latency (the time to establish a connection) is estimated to be 10 to 20 milliseconds, compared to 4G's average latency of 40 milliseconds. The maximum traffic capacity of 5G is roughly 100x greater than a typical 4G network.	(Christensson, 2020)
Gigabit	Over 1000 Mbps or 1 Gbps. A gigabit is 109 or 1,000,000,000 bits.	(Christensson, 2013)

Handhole	Handholes are used in underground systems where personnel entry is not required for installation or servicing of electrical or communications wiring. The vaults are usually not more than 48 square and 48 inside depth. Structural materials include 5,000 PSI concrete with steel reinforcing bar as required for structural load requirements. Precast concrete communication handholes have proven to be a perfect example of value-added engineering. Due to their performance and versatility, precast concrete communication handholes are the first choice for telecommunication systems. Aside from protecting the vital connections and controls for utility distribution, precast concrete is ideal for underground applications. Precast concrete is nontoxic and environmentally safe and resists buoyancy.	(E.C.B Arrbert, n.d)
Headend	A headend is a facility that accepts TV signals as input from satellites, processes them into cable-quality signals, and then distributes them to homes and cable networks. It can be considered as the master distribution centre where incoming television signals are received, selected, amplified and re-modulated, and sent for transmission to cable networks.	(Techopedia, n.d.)
Hypertext Transfer Protocol (HTTP)	Stands for "Hypertext Transfer Protocol." HTTP is the protocol used to transfer data over the web. It is part of the Internet protocol suite and defines commands and services used for transmitting webpage data. NOTE: URLs that begin with "http://" are accessed over the standard hypertext transfer protocol and use port 80 by default. URLs that start with "https://" are accessed over a secure HTTPS connection and often use port 443.	(Christensson, 2015a)
Information Communication Technologies (ICT)	ICT refers to technologies that provide access to information through telecommunications. It is similar to Information Technology (IT) but focuses primarily on communication technologies. This includes the Internet, wireless networks, cell phones, and other communication mediums.	(Christensson, 2010)
Internet Protocol Address (IP)	An Internet Protocol address (IP address) is a logical numeric address that is assigned to every single computer, printer, switch, router or any other device that is part of a TCP/IP-based network. The numerals in an IP address are divided into 2 parts: The network part specifies which networks this address belongs to and the host part further pinpoints the exact location.	(Techopedia, 2017)
Internet Service Provider (ISP)	Stands for "Internet Service Provider." An ISP provides access to the Internet. Whether you're at home or work, each time you connect to the Internet, your connection is routed through an ISP.	(Christensson, 2016)

Local Area Network (LAN)	A local area network (LAN) is a computer network within a small geographical area such as a home, school, computer laboratory, office building or group of buildings.	(Techopedia, n.d-b)
Megabit per second (Mbps or Mbit/s)	Is commonly used to measure data transfer rates of broadband Internet connections. One megabit is equal to one million bits or 1,000 kilobits. While "megabit" sounds similar to "megabyte," a megabit is roughly one eighth the size of a megabyte (since there are eight bits in a byte). Mbps is used to measure data transfer speeds of high bandwidth connections, such as Ethernet and cable modems. For example, an ISP may offer cable modem Internet access with download speeds up to 200 Mbps and upload speeds up to 20 Mbps.	(Christensson, 2006c)
Next generation access (NGA)	New or upgraded access networks that will allow substantial improvements in broadband speeds and quality of service compared to today's services. Can be based on a number of technologies including cable, fixed wireless and mobile. Most often used to refer to networks using fibre optic technology.	(Ofcom, n.d)
Next Generation Network (NGN)	An upgrade to the core or "backbone" part of the network.	(Ofcom, n.d)
Next Generation Network (NGN) - BT refers to NGN as the 21st-century Network (21CN)	A packet-based electronic communications network which is able to provide electronic communications services and to make use of multiple broadband and quality of service-enabled transport technologies, and in which service-related functions are independent of underlying transport-related technologies.	(Ofcom, 2005)
Network Service Provider (NSP)	Stands for "Network Service Provider." An NSP is a business that provides access to the Internet backbone. While some ISPs also serve as NSPs, in most cases, NSPs provide Internet connectivity to ISPs, which in turn provide Internet access to customers.	(Christensson, 2014d)
New Universal Service Obligation (USO)	Defined in the UK as speeds up to 10Mbps	(DCMS, 2016b)
Optical Distribution Framework (ODF)	A frame used to provide efficient cable connections between communication facilities. ODFs integrate fibre splicing, storage, and cable connections together in a single unit.	(Webopedia, n.d-b)

Optical Line Terminal (OLT)	An OLT (optical line terminal), also known as optical line termination, acts as the endpoint hardware device in a passive optical network. The OLT contains a central processing unit (CPU), passive optical network cards, a gateway router (GWR) and a voice gateway (VGW) uplink card.	(Fiber Optic Network Products, 2017)
Optical Network Terminal (ONT)	Same as CPE (customer premise equipment). Equipment from the telephone company that terminates its optical fibres at the customer's premises. Using electricity from the customer's AC source, the optical network terminal (ONT) converts the incoming optical signals into electrical signals for telephone, TV and Internet. See network interface device.	(PC Mag, n.d)
Passive Optical Network (PON)	Stands for "Passive Optical Network." A PON is a telecommunications network that transmits data over fiber optic lines. It is "passive" since it uses unpowered splitters to route data sent from a central location to multiple destinations.	(Christensson, 2014e)
Point of Presence (POP)	Point of presence (POP) is the point at which two or more different networks or communication devices build a connection with each other. POP mainly refers to an access point, location or facility that connects to and helps other devices establish a connection with the Internet. POP is primarily the infrastructure that allows remote users to connect to the Internet. A POP is generally present at an Internet service provider (ISP) or the telecommunication service provider. It can consist of a router, switches, servers and other data communication devices.	(Technopedia, 2017)
Splitter	The fiber optic splitter is also referred to as optical splitter, which is an integrated waveguide optical power distribution device. It plays an important role in passive optical network (EPON, GPON, BPON, FTTX, FTTH and so on) by allowing a single PON interface to be shared among many subscribers.	(Community FS, 2012)
Superfast Broadband (SFBB) – term used by UK Government to roll out NGA	Defined in the UK as speeds greater than 24Mbps, whereas Ofcom and the European Commission define it as speeds greater than 30Mbps. The Scottish and Welsh Governments also use the higher definition.	(Jackson, 2011, July 4)

Telecommunications - or telecom	The transmission of signals over long distances. It began with the invention of the telegraph in 1837, followed by the telephone in 1876. Radio broadcasts began the late 1800s and the first television broadcasts started in the early 1900s. Today, popular forms of telecommunications include the Internet and cellular phone networks. Early telecommunications transmissions used analogue signals, which were transferred over copper wires. Today, telephone and cable companies still use these same lines, though most transmissions are now digital.	(Christensson, 2014f)
Ultrafast Broadband (UFBB)	Defined in the UK as over 300Mbps	(Jackson, 2015, December 1)
Uniform Resource Locator (URL)	Stands for "Uniform Resource Locator." A URL is the address of a specific webpage or file on the Internet.	(Christensson, 2015b)
VDSL - Very-high-bitrate Digital Subscriber Line service	An upgrade to ADSL technology which allows for very fast Internet access over copper lines. It is likely to be the technology which will be used in FTTC deployments.	(Ofcom, n.d)

**All Appendix references are included in main references listed below*

Appendix B- Literature Review – ABS journal summary

Table B.1. Summary of Primary Source Titles - Chartered Association of Business Schools Academic Journals Guide (Association of Business Schools, 2018)

ABS Field/ Ranking	Four/*star Journals	Three-star Journals	One & Two-star Journals
Rural Broadband & Microbusiness	MIS Quarterly Research Policy Entrepreneurship Theory and Practice	Journal of Rural Studies, International Small Business Journal, Journal of Small Business Management	Journal of Small Business and Enterprise Development, Local Economy, Telecommunications Policy *Sociologia Ruralis, Scottish Geographical – not ABS rated*
Rural Capital & Community	Journal of Business Venturing, Environment and Planning A	Journal of Rural Studies, Entrepreneurship and Regional Development, European Planning Studies, Regional Studies, Journal of Regional Science,	*American Behavioural Scientist, Community Development, Journal of Community Development, Journal of Developmental Entrepreneurship, Rural Sociology – not ABS rated*
Innovation Management	Research Policy, Journal of Product Innovation Management, Academy of Management Review, Administrative Quarterly, Journal of Management, Organization Science	R&D Management, Academy of Management Perspectives, Technovation, Harvard Business Review, Long Range Planning	International Journal of Innovation Management, Prometheus, Technology Management

**All Appendix references are listed in main references below*

Table B.2 Publication summary of rural broadband studies in advanced western nations

Journal	Number of articles	Country Studies	ABS Field/Area
Top 10 Journals for Rural Broadband – multi-disciplinary field			
Telecommunication Policy	21	UK/EU/ USA/Canada/ Australia/NZ	SECTOR
Journal of Rural Studies	15	UK/EU/ Canada/ Australia	REGIONAL STUDIES, PLANNING & ENVIRONMENT
Sociologia Ruralis - (Journal of the European Society for Rural Sociology)	6	UK/EU	Not ABS ranked – Rural Sociology
Scottish Geographical Journal	5	UK	Not ABS ranked - Geography
Local Economy	3	UK/ USA	REGIONAL STUDIES, PLANNING & ENVIRONMENT
The Information Society	3	EU/ USA/Canada	Not ABS ranked – Information/Society
Government Information Quarterly	2	USA	INFORMATION MANAGEMENT
Information Economics & Policy	2	EU/ USA	ECONOMICS, ECONOMETRICS & STATISTICS
Journal of Small Business & Enterprise Development	2	UK/EU	ENTREPRENEURSHIP & SMALL BUSINESS MANAGEMENT
MISQ	2	Australia/ China	INFORMATION MANAGEMENT
Regional & Entrepreneurship			
International Journal of Entrepreneurial Behaviour & Research	1	UK	ENTREPRENEURSHIP & SMALL BUSINESS MANAGEMENT
International Small Business Journal	1	UK	ENTREPRENEURSHIP & SMALL BUSINESS MANAGEMENT
International Regional Science Review	1	USA	Not ABS ranked – Regional studies
Regional Studies	1	UK	REGIONAL STUDIES, PLANNING & ENVIRONMENT
Rural Entrepreneurship Conference – 12th Annual	1	EU	Not ABS ranked – Rural Entrepreneurship
The Review of Regional Studies	1	USA	Not ABS ranked – Regional studies
Geography, Psychology & Sociology			
Applied Geography	1	UK	Not ABS ranked - Geography

American Behavioural Scientist	1	USA	PSYCHOLOGY (GENERAL)
IEEE Canada Humanitarian Technology Conference	1	Canada	Not ABS ranked - Technology
Progress in Planning	1	UK	Not ABS ranked – Planning
Society & Business Review	1	UK	SOCIAL SCIENCES
Social Science Review	1	UK	Not ABS ranked – Social sciences
Information Management & Technology			
ACM Conference Proceedings	1	UK	Not ABS ranked - Computing
Business Information System Engineering	1	EU	Not ABS ranked – Information System Engineering
Industrial Management & Data Systems	1	Australia	INFORMATION MANAGEMENT
Journal of Information Policy	1	NZ	Not ABS ranked – Information Policy
Telecommunication Systems	1	EU	Not ABS ranked - Telecommunications
Telematics & Informatics	1	USA	Not ABS ranked - Technology
Operational Management			
Journal of Operational Research Society	1	UK	OPERATIONAL RESEARCH & MANAGEMENT SCIENCE
Agriculture, Government & Policy			
American Journal of Agricultural Economics	1	USA	ECONOMICS
Agriculture & Resource Economics Review	1	USA	Not ABS ranked – Agriculture & Economics
Journal of Policy, Regulation & Strategy for Telecommunications, Information & Media	1		Not ABS Ranked – Sector-specific
Transforming Government, People, Process & Policy	1	Australia	Not ABS ranked – Government, Policy

**United Kingdom (UK), European Union (EU), United States of America (USA), Canada, Australia & New Zealand (NZ). Items in CAPITAL letters are ABS Sectors.*

Appendix C– Literature Review – Key word edits

Overall search - preliminary searches were used to create a key word summary within the broader field of telecommunications and rural areas.

Inclusion – as the field expanded, it was necessary to narrow the search to ensure "broadband and rural" were used in every search to limit the scope in relevance to the topic.

Exclusion - searches using "entrepreneur" identified studies not focused on answering the research question (e.g., entrepreneurial practices or firm survival) and were excluded. Other search terms, such as "ICT4D" identified studies primarily in developing countries and poverty-reduction which were excluded.

Summary of inclusion and exclusion for primary search – to focus the search terms relevant to the research question the following themes were identified: broadband (including digital and ICT), rural, community, microbusiness, and capital. Exclusion edits for terms such as agriculture, leadership, information society, information technology, regional development, social inclusion, telecommuting and other political or conceptual terms were excluded.

Summary of inclusion for secondary concept search – human capital, social capital and community capital were included, but terms such as growth motivation and embeddedness excluded. Search strings using "entrepreneur and capital" revealed numerous human & social capital studies, but the context outside of rural community development and broadband use were eliminated (e.g., how rural Indian handloom masters use human & social capital to build business networks is an interesting study, but not related to broadband and community use).

Table C.1 Summary of the overall key word analysis. Key words not deemed relevant to answer the research question were excluded.

Key Word	Article Key Words
Broadband	Broadband adoption, Internet, next generation access, NGA, service provision, superfast, ultrafast, strategy, telecommunications
Rural	Rural areas, business, development, economy, entrepreneurship, partnerships, penalty, planning, policy, society, remote areas, countryside, village; regional development, performance
Digital	Digitalization, digital divide, digitally excluded, digital inclusion, digital inequalities, urban-rural digital divide, ICT4D, ICT, information technology, information society, telecommuting
Community	Community resilience framework, community networks, community phenomenon, community response, community of practice, community-led development, coordination, leadership and participation, resilience
Local	Local communities, behavior, conditions, localities, locational, local government
Microbusiness	Microenterprise, micro-level, micro-spatial, home business, home working, agriculture, agri-tourism rural network
Entrepreneur	Entrepreneurship, entrepreneurial practices, innovation capital, cultural capital, digital capital, firm survival, new business networks

Capital	Community capital framework, volunteer approach, rural capital framework, social capital, embeddedness, place-specific, human capital, growth motivation, business community development
Social concepts and theories	Social network theory, networks, relational and cognitive social capital, social and systems integration, social cohesion
Other concepts and theories	Authoritarianism, neoliberalism, resilience theory, market system, middle range theories, choice framework
Google Scholar – search options	"Broadband use" rural community participation Superfast broadband rural community Rural areas broadband digital divide Rural areas broadband access Rural areas ICT availability Rural communities digital divide Rural development ICT availability

Table C.2 Results of capital

Capital search
Human capital – (n=14)
Social capital – (n=24)
Environmental capital (ICT) – (n=5)
Financial capital (measurements) – (n=3)

Appendix D – Literature Review – Example of search summary

Table D.1. Example of key word search and edit process

Search string	**1st edit Results – peer reviewed; English; 2010-2019;**	**2nd edit – THESAURUS**	**3rd edit - SUBJECT**	**4TH EDIT - PUBLICATION**	**5th edit – abstract acceptance to read; in End Note**
EBSCO-"broadband" and "rural*"	122	98 broadband communication systems 75 wireless communications 20 télécommunication 17 telecommunication system 11 Internet 10 Universal service (telecommunication) 8 bandwidths 6 digital communications 6 information & communication technologies 6 information technology 6 Internet access 6 computer networks 5 economic development 5 Internet service providers 5 research 5 technological innovations 5	56 rural geography 21 digital divide 10 Internet users 8 rural development 7 ieee 802.16 (standard) 6 telecommunication policy 6 cities & towns 5 rural telecommunication 5 digital subscriber lines 4 agent (philosophy) 2 agriculture 2 antennas (electronics) 2 broadband communication systems 2 broadband communication systems -- Australia 2 cognitive radio 2 critical realism 2	36 telecommunications policy 15 government information quarterly 7 ieee communications magazine 4 American behavioral scientist 3 ieee transactions on antennas & propagation 2 mis quarterly 2 OECD observer 2 American journal of agricultural economics 1 Berkeley technology law journal 1 communications of the acm 1 computer networks 1 creative industries journal 1 ekonomski anali / economic annals 1	24 but quite a few technical papers – Telecommunications Policy; Government Info Quarterly etc.

		government policy 4 infrastructure (economics) 4 consumer behavior 3 empirical research 3 employment 3 income 3 innovation adoption 3 Internet industry 3 public-private sector cooperation 3 stakeholders 3 broadcasting industry 2 business enterprises 2 consumers' surplus 2 data transmission systems 2 decision making 2 demand (economic theory) 2 diffusion of innovations 2 economic competition 2 economic impact 2 economics 2 ethernet 2 finance 2 information networks 2 information-seeking behavior 2 Internet telephony 2 investments 2	developing countries 2 digital technology 2 educational attainment 2 electric lines 2 employment statistics 2 government policy on the Internet 2 homeowners 2 households 2 Internet access control 2 Internet industry -- economic aspects 2 long-term evolution (telecommunications) 2 radio wave propagation 2 reflexivity 2 united states. American recovery & reinvestment act of 2009 2 urbanization 2 white spaces (telecommunication) 2 2009-2017 1 3g networks 1 access control of telecommunication systems 1 attenuation (physics) 1 audio-visual equipment 1 bandwidth research 1	ieee micro 1 ieee technology & society magazine 1 ieee transactions on broadcasting 1 ilr review 1 info 1 information economics & policy 1 information society 1 information technology for development 1 journal of productivity analysis 1 journal of regulatory economics 1 journal of telecommunications management 1 journal of the operational research society 1 local economy 1 productivity 1 review of industrial organization 1	

		metropolitan areas 2 public investments 2 quality of service 2 remote access networks 2 subsidies 2 supply & demand 2 technology 2 telephone systems 2	bit rate 1 broadband communication equipment industry -- economic aspects 1 broadband communication systems -- economic aspects 1 broadband communication systems -- Great Britain 1 causal models 1 cities & towns -- china 1 communication -- equipment & supplies 1 communities 1 community involvement 1 comparative studies 1 computer graphics 1 computer users 1		

Table D.2 Example of Scopus Search String

79 document results *"rural*" AND "broadband" OR "ICT" OR "information communication tech*" AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ch") OR LIMIT-TO (DOCTYPE , "bk") OR LIMIT-TO (DOCTYPE , "ip")) AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "ECON") OR LIMIT-TO (SUBJAREA , "DECI") OR LIMIT-TO (SUBJAREA , "MULT") OR LIMIT-TO (SUBJAREA , "Undefined")) AND (LIMIT-TO (EXACTSRCTITLE , "Telecommunications Policy") OR LIMIT-TO (EXACTSRCTITLE , "IFIP Advances In Information And Communication Technology") OR LIMIT-TO (EXACTSRCTITLE , "Government Information Quarterly") OR LIMIT-TO (EXACTSRCTITLE , "Journal Of Rural Studies") OR LIMIT-TO (EXACTSRCTITLE , "Proceedings 2017 IEEE Technological Innovations In ICT For Agriculture And Rural Development Tiar 2017") OR LIMIT-TO (EXACTSRCTITLE , "Proceedings 2015 IEEE International Conference On Technological Innovations In ICT For Agriculture And Rural Development Tiar 2015") OR LIMIT-TO (EXACTSRCTITLE , "Proceedings 2016 IEEE International Conference On Technological Innovations In ICT For Agriculture And Rural Development Tiar 2016") OR LIMIT-TO (EXACTSRCTITLE , "Journal Of Small Business And Enterprise Development") OR LIMIT-TO (EXACTSRCTITLE , "European Planning Studies") OR LIMIT-TO (EXACTSRCTITLE , "Local Economy") OR LIMIT-TO (EXACTSRCTITLE , "Cases On Developing Countries And ICT Integration Rural Community Development") OR LIMIT-TO (EXACTSRCTITLE , "Entrepreneurship And Regional Development") OR LIMIT-TO (EXACTSRCTITLE , "International Journal Of Entrepreneurship And Small Business") OR LIMIT-TO (EXACTSRCTITLE , "Annals Of Regional Science") OR LIMIT-TO (EXACTSRCTITLE , "Journal Of Development Studies") OR LIMIT-TO (EXACTSRCTITLE , "International Journal Of Applied Business And Economic Research") OR LIMIT-TO (EXACTSRCTITLE , "Technovation") OR LIMIT-TO (EXACTSRCTITLE , "International Journal Of Entrepreneurial Behaviour And Research") OR LIMIT-TO (EXACTSRCTITLE , "Journal Of Rural Development") OR LIMIT-TO (EXACTSRCTITLE , "MIS Quarterly Management Information Systems") OR LIMIT-TO (EXACTSRCTITLE , "Regional Studies") OR LIMIT-TO (EXACTSRCTITLE , "Information And Management") OR LIMIT-TO (EXACTSRCTITLE , "Journal Of Business Research") OR LIMIT-TO (EXACTSRCTITLE , "Environment And Planning A") OR LIMIT-TO (EXACTSRCTITLE , "Sociologia Ruralis") OR LIMIT-TO (EXACTSRCTITLE , "International Journal Of Business Innovation And Research") OR LIMIT-TO (EXACTSRCTITLE , "Management Decision")) AND (LIMIT-TO (EXACTKEYWORD , "Internet") OR LIMIT-TO (EXACTKEYWORD , "Developing Countries") OR LIMIT-TO (EXACTKEYWORD , "Rural Areas") OR LIMIT-TO (EXACTKEYWORD , "Digital Divide") OR LIMIT-TO (EXACTKEYWORD , "Broadband") OR LIMIT-TO (EXACTKEYWORD , "Telecommunication") OR LIMIT-TO (EXACTKEYWORD , "Innovation") OR LIMIT-TO (EXACTKEYWORD , "Rural Development") OR LIMIT-TO (EXACTKEYWORD , "Information And Communication Technologies") OR LIMIT-TO (EXACTKEYWORD , "ICT") OR LIMIT-TO (EXACTKEYWORD , "Rural") OR LIMIT-TO (EXACTKEYWORD , "Telecommunications") OR LIMIT-TO (EXACTKEYWORD , "United Kingdom") OR LIMIT-TO (EXACTKEYWORD , "Rural Area") OR LIMIT-TO (EXACTKEYWORD ,*

"Entrepreneurship") OR LIMIT-TO (EXACTKEYWORD , "Information And Communication Technology") OR LIMIT-TO (EXACTKEYWORD , "Rural Economy") OR LIMIT-TO (EXACTKEYWORD , "Telecommunication Systems") OR LIMIT-TO (EXACTKEYWORD , "ICT4D") OR LIMIT-TO (EXACTKEYWORD , "Rural Society") OR LIMIT-TO (EXACTKEYWORD , "Social Capital") OR LIMIT-TO (EXACTKEYWORD , "Technology") OR LIMIT-TO (EXACTKEYWORD , "Regional Development") OR LIMIT-TO (EXACTKEYWORD , "ICTs") OR LIMIT-TO (EXACTKEYWORD , "Telecommunications Policy") OR LIMIT-TO (EXACTKEYWORD , "Business Development") OR LIMIT-TO (EXACTKEYWORD , "Infrastructure") OR LIMIT-TO (EXACTKEYWORD , "Regional Economy") OR LIMIT-TO (EXACTKEYWORD , "Rural Policy") OR LIMIT-TO (EXACTKEYWORD , "Broadband Internet") OR LIMIT-TO (EXACTKEYWORD , "Communication Technologies") OR LIMIT-TO (EXACTKEYWORD , "Ecosystems") OR LIMIT-TO (EXACTKEYWORD , "England") OR LIMIT-TO (EXACTKEYWORD , "Next Generation Networks") OR LIMIT-TO (EXACTKEYWORD , "Research") OR LIMIT-TO (EXACTKEYWORD , "Rural Broadband") OR LIMIT-TO (EXACTKEYWORD , "Rural Communities") OR LIMIT-TO (EXACTKEYWORD , "Conceptual Framework")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2009) OR LIMIT-TO (PUBYEAR , 2008) OR LIMIT-TO (PUBYEAR , 2007)) AND (LIMIT-TO (AFFILCOUNTRY , "United Kingdom"))

Table D.3 Example of database search

Database	Key word search	Number of articles	Number excluded	Number saved to EndNote	Duplicates removed	Total Articles saved
Scopus	Broadband, rural, community	134	89	45	66 -merged results with capital search – 18 duplicated removed	48
	BB, rural, capital	83	62	21		
	BB, rural and MB	26	18	8	3	5
	BB (ICT, digital, SFBB, UFBB) and rural	26	14	12	6	6
	BB (ICT, digital, SFBB, UFBB, fibre, gigabit) and rural (areas, communities, remote, countryside, village)	55	38	17	14	3
EBSCO	BB and rural areas	155	129	26	12	14
	BB, rural and community	102	86	16	14	2
	BB, rural and capital					Nothing new
	BB, rural and MB					Not a good search
	BB (ICT, NGA, digital, SFBB, UFBB, fibre, gigabit) and rural (areas, communities, remote, countryside village)	170	142	28	23	4
ProQuest	Broadband and rural areas	69	37	32	26	6
	BB, rural and community					Nothing new
	BB, rural and capital					Nothing new
	BB, rural and MB					Nothing new
	BB, (ICT, NGA, digital, SFBB, UFBB, fibre, gigabit) and rural (areas, communities, remote, countryside, village)	29	27	2	2	0

Appendix E - Ethical approval – Participant information sheet

Swansea University ethical approval form (January 2, 2020)

PARTICIPANT INFORMATION SHEET

'Next Generation Access in a Rural Community Context: An Innovation Analysis'

You are being invited to take part in some research. Before you decide whether or not to participate, it is important for you to understand why the research is being conducted and what it will involve. Please read the following information carefully.

What is the purpose of the research?

We are conducting research on next generation access (NGA), defined as full fibre to the home (FTTH) and fifth generation mobile technologies (5G), supply and demand challenges in the final few and hard to reach rural communities. Instead of addressing the problem from a national or individual level, this research engages at the community-level. The local community level is selected because there are local differences that contribute to the success or failure of rural investment (supply) and adoption (demand). Urban areas have market saturation with competitive pricing and access. Rural markets are lagging behind urban counterparts, thus increasing the digital divide.

The purpose of this study is to explore, through a community-based initiative, how to resolve the opportunities and challenges being presented by NGA and Industry 4.0.

Industry 4.0 is defined as the fourth industrial revolution, or "smart digital" revolution with the advent of the Internet of Things (IoT), precision agriculture, smart manufacturing, telehealth, teleworking and so forth. The research focuses on rural communities and microbusinesses (0-9 employees), and the access and usage of NGA as an enabler, or not, for communities to thrive (e.g. grow, develop, and prosper).

British Telecommunications (BT) sponsors the project. The research question is what else needs to sit alongside infrastructure to enable NGA to be viable for rural communities to experience the four-fold benefits of economic, social, environmental and productivity growth? The research aims to investigate what other 'capitals' (e.g. human capital, social capital, environmental capital, and financial capital) can be identified and utilized to 'unblock' the system.

Your participation in this study will take approximately 30-60 minutes depending on the participant's time. Interviews will be conducted face to face or by telephone, and a final NGA self-assessment will be conducted by email, telephone, or face to face.

Who is carrying out the research?

Sian Cope is collecting the data from the School of Management at Swansea University. The Supervisors are Professor Paul Jones and Dr Louisa Huxtable-Thomas from the School of Management at Swansea University. The School of Management Research Ethics Committee have approved the research.

What happens if I agree to take part?

Participants will be asked questions about their experiences of advanced broadband access,

use, potential skills development, and potential intended use of next generation access (NGA) FTTH and 5G technologies. Questions will be asked to ascertain if participants have heard about Industry 4.0 and how this may or may not enhance the four-fold benefits of economic, social, environmental and productivity growth within their "final few" and hard to reach rural community.

Are there any risks associated with taking part?

The School of Management Research Ethics Committee have approved the research.

Data Protection and Confidentiality

Your data will be processed in accordance with the Data Protection Act 2018 and the General Data Protection Regulation (GDPR). All information collected about you will be kept strictly confidential. The researcher/research team will only view your data.

All electronic data will be stored on a password-protected computer file at Swansea University School of Management and on the / laptop. All paper records will be stored in a locked filing cabinet in the researcher's home office. Your consent information will be kept separately from your responses to minimise risk in the event of a data breach.

Please note that the data collected for the study will be made anonymous, unless the participant notifies otherwise. By coding all the participants' names from the outset (e.g. interviewee 1, 2, 3 and so forth) and by using a pseudonym for the rural case study areas. Thus, it will not be possible to identify and remove your data at a later date, should you decide to withdraw from the study. Therefore, if at the end of this research you decide to have your data withdrawn, please let us know before you leave.

Please note that if data is being collected online, once the data has been submitted online you will be unable to withdraw your information.

The lead researcher (or supervisor, if student research) will take responsibility for data destruction and all collected identifiable data will be destroyed on or before January 2026. PhD data is usually stored for approximately five years as per University guidelines.

What will happen to the information I provide?

An analysis of the information will form part of our report at the end of the study and may be presented to interested parties and published in scientific journals and related media. *Note that all information presented in any reports or publications will be anonymous and unidentifiable.*

Is participation voluntary and what if I wish to later withdraw?

Your participation is entirely voluntary – you do not have to participate if you do not want to. If you decide to participate, but later wish to withdraw from the study, then you are free to withdraw at any time, without giving a reason and without penalty.

Data Protection Privacy Notice

The data controller for this project will be Swansea University. The University Data Protection Officer provides oversight of university activities involving the processing of personal data and can be contacted at the Vice Chancellors Office.

Your personal data will be processed for the purposes outlined in this information sheet. Standard ethical procedures will involve you providing your consent to participate in this study by completing the consent form that has been provided to you.

The legal basis that we will rely on to process your personal data will be processing is necessary for the performance of a task carried out in the public interest. This public interest justification is approved by the School of Management Research Ethics Committee, Swansea University.

The legal basis that we will rely on to process special categories of data will be processing is necessary for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes.

How long will your information be held?

We will hold any personal data and PhD response data for as long as the Swansea University GDPR guidelines dictate. GDPR guidelines state that personal data shall be kept for no longer than is necessary for the purposes for which it is being processed.

Automated decision making and profiling [only required if applicable].

Not applicable.

What are your rights?

You have a right to access your personal information, to object to the processing of your personal information, to rectify, to erase, to restrict and to port your personal information. Please visit the University Data Protection webpages for further information in relation to your rights.

Any requests or objections should be made in writing to the University Data Protection Officer: -

University Compliance Officer (FOI/DP)
Vice Chancellor's Office
Swansea University
Singleton Park
Swansea
SA2 8PP
Email : dataprotection@swansea.ac.uk

How to make a complaint

If you are unhappy with the way in which your personal data has been processed, you may in the first instance contact the University Data Protection Officer using the contact details above.

If you remain dissatisfied, then you have the right to apply directly to the Information Commissioner for a decision. The Information Commissioner can be contacted at: -

Information Commissioner's Office,
Wycliffe House,
Water Lane,
Wilmslow,
Cheshire,
SK9 5AF

www.ico.org.uk

What if I have other questions?

If you have further questions about this study, please do not hesitate to contact us:

Sian Cope
School of Management at
Swansea University
E: 890403@swansea.ac.uk

Dr Louisa Huxtable-Thomas
School of Management at
Swansea University
E: l.a.huxtable-thomas@swansea.ac.uk

Appendix F – Ethical approval – Participant consent form

Rural Broadband Stakeholder Consent Form

'Next Generation Access in a Rural Community Context: An Innovation Analysis'

This consent form is to be completed after reading the *Participants Information Sheet*. This form is to ask rural broadband stakeholders' permission to interview them about next generation access (NGA), or 'full fibre and 5G', supply and demand opportunities and challenges, particularly in relation to the UK Government's vision and ambition for Industry 4.0. The 'final few' and hard to reach rural areas are a complex supply and demand challenge to overcome. This research will consider how both financial and non-financial capital contributions can add value to this process. The aim of this research is to understand how supply and demand stakeholders can mutually learn and cooperate to resolve the digital divide.

Name and Contact details of the principal researcher: Sian Cope: email 890403@swansea.ac.uk. Supervisors: Dr Louisa Huxtable-Thomas: email l.a.huxtable-thomas@swansea.ac.uk and Professor Paul Jones: email w.p.jones@swansea.ac.uk.

		Participant initial
1.	I (participant) confirm that I have read and understand the *Participant Information Sheet* for the above study (February X, 2020) which is attached to this form.	
2.	I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reasons.	
3.	I understand what my role will be in this research, according to the *Participant Information Sheet*, and all my questions have been answered to my satisfaction.	
4.	I understand that I am free to ask any questions at any time before and during the study.	
5.	I have been informed that the information I provide will be safeguarded.	
6.	I am happy for the information I provide to be used (anonymously using pseudonym's) in academic papers and other formal research outputs.	
7.	I am willing for my information to be audio recorded.	
8.	I have been provided with a copy of the *Participant Information Sheet*.	
9.	I agree to the researchers processing my personal data in accordance with the aims of the study described in the *Participant Information Sheet*.	

Thank you for your participation in this study. Your help is very much appreciated.

_____ _____

Print name of participant Signature Date

_____ _____

Print name of researcher Signature Date

This study is being conducted by Swansea University, School of Management.

When complete: Original copy for participant, one copy to be retained by researcher

Appendix G – Case study protocol template

To ensure reliability, reflexivity, validity and trustworthiness for qualitative research a case study protocol (Yin, 1994) and a case study checklist (Brereton et al., 2008, p.7).

Table H.1 The case study protocol for this research

Heading	Task	Completed	Section
1. Background	a) identify previous research on the topic.	Yes	1.3 (Research background) 3.5 – 3.6 (rural broadband studies).
	b) define the main research question being addressed by this study.	Yes	1.7 (RQs) – original RQ1, 2 & 3.
	c) identify any additional research questions (RQs) that will be addressed.	Yes	3.9 (Conclusion of literature review) - modified RQ2 only.
2. Design	a) identify whether single-case or multiple-case and embedded or holistic designs will be used and show the logical links between these and the RQs.	Yes	4.5 (Research methodology) – single intrinsic unique case study capturing supply and demand complexities.
	b) describe the object of study.	Yes	2.1.4 (Regional context: Pembrokeshire) & 4.4 (Research design) unit of analysis – rural community.
	c) identify any propositions or sub-questions derived from each research question and the measures to be used to investigate the propositions.	N/A	N/A
3. Case Selection	a) Criteria for case selection.	Yes	2.1, 2.2 & 2.3.6 (Research context). 4.7.1 (Overview of deep rural case study) - final few & hard to reach rural area.

4. Case Study Procedures and Roles	a) Procedures governing field procedures.	Yes	4.7.2 (Field procedures) – access, ethics, health & safety.
	b) Roles of case study research team members.	N/A	N/A
5. Data Collection	a) identify the data to be collected.	Yes	4.8 (Data collection methods)– observations & document analysis (May 2019-March 2020). Interviews (Jan 2020-March 2020).
	b) define a data collection plan.	Yes	4.8 (Data collection methods)– summary of procedures 1-VI for multi-method data collection.
	c) define how the data will be stored.	Yes	4.9 (Ethics, access & timeframe)– at home, encrypted password documents, NVivo, laptop & University as per ethical guidelines. (Appendix E)
6. Analysis	a) identify the criteria for interpreting case study findings.	Yes	4.11 (Academic rigour)– nation and local-level thematic analysis – *a priori* coding in relation to HVS & RSCAT interview guides. (Appendix J)
	b) the analysis should take place as the case study task progresses.	Yes	Section 4.8 (Data collection methods) – staged data collection and analysis – divergence records as changes to case study area transpired – Section 4.10. and 5.4.1 – pilot study findings from 2016, 2018/2019 and 2020. Overall multi-method data analysis (Section 4.12.1)

	c)* the plan should identify which data elements are used to address which research question & how the data elements will be combined to answer the question.	Yes	Procedure V supply interviews (RQ1 & 2) – Section 4.8.5. Procedure VI – (RQ1 & 2) demand interviews – Section 4.8.6. HVS & RSCAT instrument (RQ3) – Section 4.10 & (Appendix I). Summary of RQ & Instruments – 4.10.5, Table 4.5
	d)* ensure that you identify alternative explanations of the results & identify any information that is required to distinguish between these.	Yes	4.10 – divergence records.
7. Plan Validity (see Figure 2.3 & Chapter 5 in Yin (2003))	a) general: check plan against Höst and Runeson's (2007) checklist items for the design & the data collection plan.	Yes	Appendix H
	b) construct validity - show that the correct operational measures are planned for the concepts being studied. Tactics for ensuring this include using multiple sources of evidence, establishing chains of evidence, expert reviews of draft protocols & reports.	Yes	Section 6.10 – Credibility, reflection, reliability & validity – organising NVivo – audit trail, annotations, cross-referencing, research journal for coding decisions, coding framework for operational definitions. Analytic memos. Pilot study & expert feedback (Section 4.10) A3 maps for code landscaping & diagramming (Appendix J). Triangulation between observations, interviews & document analysis (throughout Chapters 5 & 6). Appendix J – detailed researcher reflection

			analysis (J.1), thematic analysis checklist (J.2) & OVERALL detailed data analysis process (J.3).
	c) internal validity - show a causal relationship between outcomes and intervention/treatment (for explanatory or causal studies only).	N/A	N/A
	d) external validity – identify the domain to which study finding can be generalized. Tactics include using theory for single-case studies & using multiple-case studies to investigate outcomes in different contexts.		Section 8.6.2 – mutual business thinking is universal & is generalised. Section 8.5.3 – practical contribution are generalisable assessment & visualisation tools.
8. Study Limitations	Specify residual validity issues including potential conflicts of interest (i.e. that are inherent in the problem, rather than arising from the plan).	Yes	Cultural & political bias/capital – this study focused on product to market, but these other capitals can affect problem area resolution.
9. Reporting	Identify target audience, relationship to larger studies (Yin, 2003).	Yes	Academic, commercial & governmental audiences (Section 8.6)
10. Change Record (divergence)	This should be a list or table summarizing the main updates and changes embodied in each version of the protocol and (where appropriate), the reasons for these.	Yes	Section 4.10 – divergence records relating to changes in the instrument design as a result of a change to case study area (4.10.2, 4.10.3, 4.10,4) & an explanation in Section 4.4 (Research design) & 7.5 (Revised conceptual framework outcome).
11. Schedule	Give time estimates for all of the major steps: Planning, Data Collection, Data Analysis, Reporting.	Yes	Data collection process & timeframe – Section 4.8, Figure 4.3. Chronology of summary of data

			collection – Section 4.8.7, Figure 4.4. Data analysis & reporting – 4.11, 4.12.1 (OVERALL SUMMARY).
	Note Data Collection & Data Analysis are not expected to be sequential stages.	Yes	This is multi-method study over interlocking timeframes – Section 4.12.1 Overall summary
12. Appendices	a) Validation: report results of checking plan against Höst & Runeson's (2007) checklist items.	Yes	See Appendix H.
	b) Divergences: update while conducting the study by noting any divergences from the above steps.	Yes	Detailed above in divergence records.

Appendix H - Case study checklist

As a secondary step to ensure reliability, reflexivity, validity & trustworthiness. Case study checklist developed by Runeson & Host (2008, p. 160, Table 12 Researcher's checklist).

Table I.1 Case study checklist for this thesis

Task	Checklist questions	Response	Section
Case study design	1. What is the case & its units of analysis?	Rural community	1.4 (research context), 2.1.4 (regional context), 4.4 (research domain), 4.5.2 (intrinsic case study), 4.7.1 (in-depth unique rural case study).
	2. Are clear objectives, preliminary research questions (RQs), hypotheses (if any) defined in advance?	Yes	1.2 (research aim & OBJs), 1.7 (original RQs), 3.10 (modified RQs from literature review).
	3. Is the theoretical basis—relation to existing literature or other cases—defined?	Yes	1.1 (four-fold capitals), 1.5 (research problem – CSFs human & social capital), 1.6 (research gap), 3.2.4 (academic field) 3.5 (rural broadband capital studies).
	4. Are the authors' intentions with the research made clear?	Yes	1.1 (purpose – how to get product to final few market) & 4.4 (research domain – financial constraints currently blocking system) – non-financial capital investigations required.
	5. Is the case adequately defined (size, domain, process, subjects…)?	Yes	2.1.4 (DEFRA F2, hamlet – sparse dwellings, white premises), 4.5.2 (case study design selection).
	6. Is a cause–effect relation under study? If yes, is it possible to distinguish the cause from other factors using the proposed design?	N/A	N/A
	7. Does the design involve data from multiple sources (data triangulation), using multiple methods (method triangulation)?	Yes	4.7.4, Figure 4.2 (guide to case study report – context plus multiple data sources) & 4.8 (phased data collection procedures I-VI including academic literature, grey literature (tiers 1, 2, 3), observation data, interview data, document analysis).

	8. Is there a rationale behind the selection of subjects, roles, artefacts, viewpoints, etc.?	Yes	1.3 (research background), 1.4 (research context), 2.1 (Wales – final few & hard to reach), 2.2 (rural), 2.3 (rural stakeholders).
	9. Is the specified case relevant to validly address the RQs (construct validity)?	Yes	4.7.1 (unique final few & hard to reach case study, supply & demand challenge).
	10. Is the integrity of individuals/organizations considered? Preparation for data collection.	Yes	4.9 (ethical considerations).
	11. Is a case study protocol for data collection & analysis derived (what, why, how, when)? Are procedures for its update defined?	Yes	4.7 (case study protocol), 4.8 (data collection methods), 4.10 (instrument designs) & 4.11 (thematic network data analysis). 4.12.1 (overall summary)
	12. Are multiple data sources & collection methods planned (triangulation)?	Yes	4.8, Figure 4.3 (2016. 2018/2019, 2020 process & timeframe – phased procedural approach observations, interviews, document analysis).
	13. Are measurement instruments & procedures well defined (measurement definitions, interview questions)?	Yes	4.10 (instrument design) & Appendix I (semi-structured interview guides) *A priori* codebook (Appendix K).
	14. Are the planned methods & measurements sufficient to fulfil the objective of the study?	Yes	3.9, Table 3.15 (conclusion of literature review related to OBJs by section) & 4.10.5 (conclusion of research methodology – HVS & RSCAT to answer RQs).
	15. Is the study design approved by a review board, & has informed consent obtained from individuals & organizations?	Yes	4.6 (overall research design), 4.9 (ethics), Appendices E & F (University approval & consent forms).
Collecting Evidence	16. Is data collected according to the case study protocol?	Yes	5.1.1, Figure 5.1 (observations, interview & document analysis).
	17. Is the observed phenomenon correctly implemented (e.g. to what extent is a design method under study actually used)?	Yes	4.6 (overall research design followed).
	18. Is data recorded to enable further analysis?	Yes	4.7.2 (field procedures) digital recording, NVivo, manual records & Trint transcripts.

	19. Are sensitive results identified (for individuals, the organization or the project)?	N/A	N/A
	20. Are the data collection procedures well traceable?	Yes	5.2 (observation findings – nation-level), 5.3 – 5.9 (supply & demand interview findings), 5.10 (document analysis).
	21. Does the collected data provide ability to address the research question? Analysis of collected data.	Yes	5.2.5 (observation summary RQs 1-3), 5.4.5 & 5.6.8 (supply interview summary RQs 1-3), 5.8.9 (demand interview summary RQs 1-3). 5.11 (conclusion nation-level RQs 1-3). 6.7 (summary of capital contributions RQ1). 6.8 (mutual learning & cooperative interplay RQ2). 6.9 (HVS outcome RQ3).
	22. Is the analysis methodology defined, including roles & review procedures?	Yes	4.11 (Academic rigour - data analysis methods – thematic network analysis & *a priori* coding). 4.12 (reliability, reflexivity, validity & trustworthiness – audit trails, member checks, triangulation, thick description and so forth). Appendix J (review checklists & procedures).
	23. Is a chain of evidence shown with traceable inferences from data to RQs & existing theory?	Yes	Throughout Chapter 5 (nation-level), Chapter 6 (local-level). Human & social capital clearly evidenced. RQs answered in 5.11 & 6.11 (conclusions).
	24. Are alternative perspectives & explanations used in the analysis?	No	In Vivo coding used to reflect participants responses & triangulation throughout Chapters 5 & 6.
	25. Is a cause–effect relation under study? If yes, is it possible to distinguish the cause from other factors in the analysis?	N/A	N/A

	26. Are there clear conclusions from the analysis, including recommendations for practice/further research?	Yes	7.4 (four potential intervention areas – case study area, complex ecosystem analysis, open & co-creation IM analysis at nation & local level). 7.5 (new revised conceptual framework outcome). 7.6 (gaps fulfilled in literature). 8.4 (contribution to knowledge). 8.5 (recommendations for practice). 8.6 (implications for policy & practice). 8.8 (limitations). 8.9 (future research).
	27. Are threats to the validity analysed in a systematic way & countermeasures taken? (Construct, internal, external, reliability).	Yes	Section 6.10 (credibility, reflection, reliability & validity) - data organisation, audit trails, member checks, quotation maps, triangulation & so forth.
Reporting	28. Are the case & its units of analysis adequately presented?	Yes	4.7.1 (Overview of in-depth rural case study) 5.8 (Splits-Ville case study area thick description). 7.4 (application & value of this research) & 7.4.1 (NED capital application for Splits-Ville area).
	29. Are the objective, the RQs & corresponding answers reported? 30. Are related theory & hypotheses clearly reported?	Yes	7.5 (revised conceptual framework to OBJs & RQs). 8.3 (answers to RQs). 8.4 (contributions to knowledge).
	31. Are the data collection procedures presented, with relevant motivation?	Yes	4.8 (phased approach). 4.12.1 (overall multi-method summary). Chapter 5 – complex ecosystem (nation-level observations, interviews & document analysis). Chapter 6 – productivity & collective action (local-level analysis).

	32. Is sufficient raw data presented (e.g. real-life examples, quotations)?	Yes	Chapter 5 (31 quotation maps) & complexity of network build analysis (5.10.2). Chapter 6 (26 quotation maps). Chapter 7.4 (four potential intervention areas – network analysis, net HC-SC illustration, reflexive researcher network analysis).
	34. Are threats to validity analyses reported along with countermeasures taken to reduce threats?	Yes	6.9 - Member checks.
	35. Are ethical issues reported openly (personal intentions, integrity issues, confidentiality).	Yes	4.3.2 (research philosophy – pragmatism, underlying assumptions). 4.9 (ethics) & Appendices E & F (University & Participant consent forms).
	36. Does the report contain conclusions, implications for practice & future research?	Yes	8.2 (summary of findings), 8.3 (answers to RQs), 8.4 (contributions to knowledge), 8.5 (contributions to practice), 8.6 (implications for key stakeholders) 8.9 (future research).
	37. Does the report give a realistic & credible impression?	Yes	Chapter 7 (discussion & four practical intervention areas) & Chapter 8 (practical contributions)
	38. Is the report suitable for its audience, easy to read & well structured?	Yes	Chapter 1 (introduction – topic is relevant to all stakeholders particularly post COVID-19) & Chapter 8 (conclusions – summarises relevance for new 21st century thinking to problem area resolution).

Appendix I – Semi structured interview guides

The following instrument guides are the original guides used during pilot testing. Modifications and reductions to RSCAT were made post pilot testing feedback.

I.1 Hybrid Value System (HVS) – supply interviews

Hybrid Value System (HVS) Interview Guide

Rural Gigabit Connectivity (RGC) rollout - January 2020

Dear ….

Thank you for taking part in this interview. The focus of this research is on the Rural Gigabit programme and reaching the final few and hard to reach rural areas.

Before we start, I need to do a bit of housekeeping.

1. Introduction

- Confidentiality, anonymity, and consent
- Right to withdraw
- What we will do with the data
- Recording the interview
- Handout or email - *Participation Information Sheet* and *Consent Form* for their records.

If you prefer not to have the interview recorded, it is not a problem - notes will be taken instead to record your answers.

Are you happy for me to record this interview?

2. Overall Structure

The overall structure of this interview will be divided into three sections:

I. Section 1 – Industry 4.0 and rural communities
II. Section 2 – identification of various capital contributions
III. Section 3– basic demographic questions

There are 25 questions and will take 30-45 minutes, depending upon length of your answers:

SECTION 1: Industry 4.0 and current challenges

Q.1. What is your current role?

- *Job title etc.*
- *How long have they been in their role?*

Q.2 What do you think about Industry 4.0 in rural communities?

- *Prompt – I do not want to assume – the aim is to get a benchmark of understanding of this new wave of innovation.*

Q.3 Do you think rural communities will use the service?

- *Do you think rural areas will benefit from the opportunities?*

Q.4 What barriers are stopping you from getting the job done?

- *Prompt – are there multiple barriers or one big problem*

Q.5 Do you think there is a solution/s to resolve the barriers?

- *What would need to happen?*
- *Do some barriers have a solution?*
- *How would you like the barriers to be resolved?*

Q.6. Is there **anything else** around Rural Gigabit supply issues that you would like to mention that I didn't ask?

SECTION 2: Identification of various capital contributions

Now I want to talk about the types of people and the skills required to get the job done.

2.1 People - skills, knowledge, attitudes, motivations

Q.7. In your experience, what kind of people and skills do you find **valuable** in getting the job done - 'full fibre and 5G' to the final few and hard to reach communities?

- Prompt - *What sort of skills, experience, attitudes, motivations do you value?*
- *Within the supply community?*
- *Within the rural or demand community?*

Q.8. What about your own skills or contributions?

- *What role do you play?*
- *OR*
- Beyond your industry is there a role that is similar to the role you play?
- *Prompt – Principal of a School able to manage multiple stakeholders or Conductor of an Orchestra?*

Q.9. Do you see yourself as a **mediator** between stakeholders?

- *In what way – to which stakeholders?*
- *Are mediators required to help stakeholders get things done?*

Q.10. Is there anything that **hinders or blocks** you from getting the job done in this context?

- *Prompt – lack of skills, attitudes, lack of motivation*
- *Within the supply community?*
- *Within the rural or demand community?*

Q.11. **Is there anything else** about skills, experience, attitudes, and roles that I didn't ask that you wanted to share?

- *Prompt – with in the supply community?*
- *Within the rural or demand community?*

2.2 Social capital – relationships and networks.

Now, can we talk about the relationships and networks you need to get things done – particularly in the exchange of information and resources.

Q.12. In your experience, what relationships and networks do you find **valuable** in getting things done in a Rural Gigabit context?

- *Prompt – What factors or attributes do you value?*
- *What about trust?*
- *What about teamwork and collaboration?*
- *How easy is it to exchange information or ideas?*

Q.13. Are there relationships or access to networks that are lacking – or you would like to have or **need to develop** to get things done in a Rural Gigabit context?

- *Do you need to build any relationships?*

Q.14. Is there anything that **hinders** your relationships and networks in getting things done in Rural Gigabit context?

- *People moving jobs – lack of empathy – lack of motivation*

Q.15. Is there anything I didn't ask that you wanted to share about relationships, networks, and skills?

2.3 Financial Capital

Q.16. Do you have any comments about the **current funding model** – how is it working?

- *Prompt – Vouchers, Openreach Community Fibre Partnerships and so forth*
- *New Community Broadband Fund - £10m*
- *Swansea City Region*
- *What is not working?*
- *What can be done to improve the scheme?*

Q.17. In your opinion, what are the **key financial challenges** in supplying the final few and hard to reach in Wales?

- *What are the barriers?*
- *Can the costs be spread?*
- *Can you identify any pain points or "hot spots" that you would like to address?*

Q.18. What about the "clawback" clause – is it working?

- *Have these funds been re-invested?*

Q.19. In an **ideal world**, how would you like to fund the final few and hard to reach areas?

- *What needs to happen in the supply arena?*
- *What needs to happen in the demand arena?*

2.4 Environmental Capital

Climate change is a concern for many people.

Q.20. Given your role – do you think there are the environmental benefits of Industry 4.0 and the rural gigabit rollout?

- *E.g. Reduced travel?*
- *Any eco-innovation ideas?*

Q.21. Given your role – do you have any environmental concerns?

- *Prompt – if so, what are they? Have they been addressed?*
- *Do they have any environmental suggestions?*

FINAL QUESTION

Q.22. Is there anything that you want to share that I didn't ask?

SECTION 3: Basic demographic questions

This section is optional. A few final demographics questions.

Q.23. What age range are you?

a) 18-35 b) 36-45 c) 46-55 d) 56-65 e) 65 or older

Q.24 Gender?

a) Male b) Female

Q.25. What level of education?

a) Some college credit, no degree b) Trade/technical/vocational training

c) Undergraduate or master's degree d) Professional degree

e) Doctorate degree f) Other – please specify

Thank you for your time and taking part in my PhD research project - it is very much appreciated!

I2. Rural Social Capital Assessment Tool (RSCAT) – demand interviews

**Please note – this is the original RSCAT with HVS. It was modified after demand interviews (Section 4.10.4).*

Rural Social Capital Assessment Tool (RSCAT)

Interview Guide - January 2020

Dear ….

Thank you for taking part in this interview. The focus of this research is on the recent UK Government funding and reaching the final few and hard to reach rural areas with 'full fibre and 5G'.

Before we start, I need to do a bit of housekeeping.

1. Introduction

- Confidentiality, anonymity, and consent
- Right to withdraw
- What we will do with the data
- Recording the interview
- Handout or email - *Participation Information Sheet* and *Consent Form* for their records.

If you prefer not to have the interview recorded, it is not a problem - notes will be taken instead to record your answers.

Are you happy for me to record this interview?

2. Structure of RSCAT Interview Guide

The time taken to answer these questions can be 40-60 minutes depending on the participants answers and availability. The interview guide consists of three parts:

Part I - Leaders only

1A. Define rural community

1B. Leaders, institutions, trust, solidarity, and collaborative action

1C. Experience of getting Broadband – before Engagement Officers

1D. Experience of getting Broadband – after Engagement Officers

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Part II – Social Capital – all parties

2B. Benchmarking trust

2C. Benchmarking collaborative action and cooperation

Part III – Industry 4.0 – all parties

2A. Current experience of broadband and mobile

2B. Awareness of Industry 4.0 – do they want it?

2C. Financial contributions

2D. Environmental benefits or concerns

Part IV

3A. General demographic questions – for statistical purposes

Part I - Rural Community – *Leaders Only*

1A. Define the rural community

Q.1. How long have you lived in this community?

- *How many years?*

Q.2 Why did you move to this community?

- *What characteristics or reasons?*

Q.3 How would you define/describe this rural community?

- *How does the council define it - ward, hamlet, village – the geographical boundaries*
- *How many houses?*
- *Where are the….*
    - *health services (both formal and informal)?*
    - *markets, shops, and other commercial establishments?*
    - *primary school?*
    - *churches (places of worship)?*
    - *cultural and recreational areas? (where do you spend your free time)*

Q.4. Do you think the number of people living in this community, in the last three years, has *Increased, decreased, remained the same, do not know?*

- *What are the two main reasons or evidence for this?*
- *Purpose - In or out migration*

Q.5. How would you describe the **standard of living** in this community?

- *Prompt – wealthy, well-to-do, average, poor, very poor, don't know*

1.B Leaders and Institutions

Q.6. Who are the main leaders in this community?

- *Do you know how they become leaders?*
- *Do you know how leaders are selected?*
- *If not you, are any members of your household involved?*

Q.7. How are decisions made within this community?

- *What is the role of the community leaders?*
- *How are community members involved?*
- *PROBE - role of formal leaders, informal leaders*

Q.8. What institutions, groups or associations exist in the community?

- *Who are the main players?*
- *List all the organisations, **formal and informal**, that exist in the community.*
  - *Business groups - Community development committee - Cooperative (agriculture, crafts, fishing) - Health committee - Sports groups - Cultural group - Civic group - Other – please specify*

Q.9. Which people or organisations help or support these community-based organisations?

- *Location and **funding** of these groups*
  - *Community centre - Personal homes - Churches or religious buildings*
  - *Health centre – School - Government building - Business/commercial buildings - Other – please specify*

Q.10. Overall, how would you rate the ***spirit of participation*** in this community?

- *Very low, low, average, high, very high or do not know?*

1.C Experience of getting broadband – before Engagement Officers

Q.11. Why did you get involved as a leader?

- *What motivated you?*
- *Why were you proactive?*
- *What skills, experience, or attitude did you have to help make this happen?*

Q.12. Can you describe in detail your previous experience of getting broadband and mobile to your community?

- *What were the challenges?*
  - *Were there community groups that played an important role?*
  - *What kinds of responses did you get from the local government?*
    - *From other organisations?*
    - *From the rest of the community?*
  - *What kinds of obstacles did you have to deal with?*
  - *What was the outcome of the effort?*
  - *Resources tapped?*
  - *Sources of resistance?*

Q.13. Why do you think the attempt **failed**?

- *What could you have done differently to make the effort more successful?*
- *Any sources of resistance*

Prior to the Local Authority Engagement Officers coming to your area were you aware of funding opportunities?

Q.14. Were you aware of the government funding options to supply NGA?

- *If so, how so?*
- *If not, why not?*

Q.15. Were you aware of the community-led guidance and six different funding options suggested by the UK Government Department for Digital, Media and Culture (DCMS) and Building Digital UK (BDUK)? https://www.gov.uk/government/publications/community-led-broadband-schemes/introduction-to-community-led-schemes.

- *If so, how so?*
- *If not, why not?*

Q.16. Were you aware of BT/Openreach Community Fibre Partnership Programme?

- *If so, how so?*
- *If not, why not?*

Q.17. Were you aware of any other financial capital options that I have not mentioned?

- *Prompt – crowdsourcing, fundraising and so forth*

Q.18. Were you aware of any income generating ideas from 'full fibre or 5G' supply?

- *Prompt – social enterprise, co-operatives, revenue models*

1D. Experience of getting Broadband – with the Engagement Officers

Q.19. What did you think when the Broadband Engagement Officers arrived?

Q.20. How would you describe the experience so far?

- *How is communication disseminated?*

Q.21. How has the community responded?

- *Comments from the community?*
- *Do people talk about broadband?*

Q.22. When the Broadband Engagement Officers present the supplier options for the community to choose – how will the decisions be made?

- *The leaders decide or the community decides*

Part II – Social capital – rural community - Both

2.A Benchmarking trust

Q.23. Overall, do you think that people in this community generally trust one another in matters of *collaboration/teamwork*?

- *Do trust, do not trust, don't know*
- *What about lending and borrowing – do people ask one another?*

Q.24. Do you think over the last few years this level of trust has gotten better, gotten worse, or stayed about the same?

- *Better, remained the same, worse, or don't know*

Q.25. Please tell me if you agree or disagree with the following statements:

a. Most people in the community are basically honest and can be trusted.

b. People are only interested in their own welfare.

c. If you have a problem, there is always someone to help.

d. I do not often pay attention to the opinions of others in the community.

e. I feel accepted as a member of this community.

2.B. Benchmarking cooperation

Q.26. In your opinion, is this community generally peaceful and harmonious or disagreeable and conflictive?

- *Or don't know*
- *Any examples?*

Q.27. Suppose two people in this community had a dispute with each other. Who do you think would primarily help resolve the dispute?

- *No one – people work it out between themselves*
- *Family/household members*
- *Neighbours*
- *Community leaders - Religious leaders - Judicial leaders*
- *Other – specify*
- *Do not know*

Part III – Current Broadband and Industry 4.0

Now, I would like to ask a few questions about your current use and experience of broadband.

Q.28. Do you use the Internet?

- *If no, any reason why?*

Q.29. What do you currently use it for?

- *Do you work from home?*
- *Would you like to work from home?*

Q.30. How would you describe your current home broadband and mobile service?

- *Slow, unreliable, average, fast, reliable, don't know*
- *What do you currently pay for broadband/mobile?*

Q.31. Do you want a faster service and how would it benefit you?

- *Prompts – four-fold benefits?*

Q.32. The UK Government is investing in 'full fibre and 5G' technologies - are you **aware of Industry 4.0**?

- *If so, how so?*

Q.33. Do **you want 'full fibre and 5G'** services?

- *If Yes – can you, please explain what you would want it for?*
- *If No – can you, please explain why not?*

3.A. Human Capital - Skills and Awareness – benchmarking only

I would now like to speak to you now about demand for the service.

Q.34 Are you **aware** of what faster broadband can do for rural communities?

- *If yes, how so*
- *If not, would they like to know?*

Q.35. Are you **aware** of the opportunities with Industry 4.0?

- *If so, how so?*
- *Tele-health, tele-working, Internet of Things*
- *If not, why not?*

Q.36. Would you like to develop your **knowledge**/**understanding** of Industry 4.0 and 'full fibre and 5G' opportunities?

- *Yes – what is your interest?*
- *No – if not, can you please explain why?*

Q.37. Are you **aware** of the UK Government 21st- century Digital Skills training?

- 5 Essential Skills – communication, handling information and content, transacting, problem solving, being safe and secure online?

Q.38. Would you like to develop your digital skills?

- If yes, why?
- If no, any reason why not?

Q.39. Do you know if your community provides **training** for 'full fibre and 5G' and the incoming fourth industrial revolution?

- *If so, how so?*
- *If no, where would you like to go?*

Q.40. Do you want your community to provide training for Industry 4.0?

- If yes, how would you like the training?
- Community centre, library, or webinars?

Q.41. NGA Self-Assessment - If I were to describe a ladder with steps numbering zero (bottom) to 11 (top). The top of the ladder represents the best possible 'digital life' for you (THRIVING), the middle of the ladder (STRUGGLING) and the bottom of the ladder (SURVIVING).

- If I said THRIVING (8-11) – is to be proficient and confident in 21st century digital skills.
- If I said STRUGGLING (4-7) – is moderately proficient but need help.
- If I said SURVING (0-4) – you don't yet feel confident, but would like to learn
- On which step of the ladder would you say you personally stand at this time?
- On which step of the ladder would you like to stand in 5 years' time?

3.B. Financial Capital

If not already answered.

Q.42. What do you currently pay for broadband and mobile?

Q.43. What would you pay for 'full fibre and 5G' services?

Q.44. Would you be willing to contribute to a community effort to provide training?

3.C Environmental Capital

Climate change is a concern for many people.

Q.45. In your opinion – do you see any environmental **benefits** of 'full fibre and 5G'?

- *Example, less travel*
- *Working from home*
- *Green electricity inputs*

Q.46. Do you have any environmental **concerns** about 'full fibre and 5G'?

- *How might any concerns be alleviated?*

FINAL QUESTION

Q.47. Is there anything else that you would like to say that I didn't ask?

Part III - General demographic questions - For All Participants

Q.48. Age

a) 18-35 b) 36-45 c) 46-55 d) 56-65 e) 65 or older

Q.49. Gender

a) Male b) Female

Q.50. Employment status

a) Employed – FT, PT, Self b) Unemployed

c) Retired d) Student e) Other

Q.51. Occupation

Q.52. Education

a) Some college credit, no degree

b) Trade/technical/vocational training

c) Undergraduate or master's degree

d) Professional degree

e) Doctorate degree

f) Other – please specify

FOR MICROBUSINESSES ONLY

Q.53. How many years has the business been going?

Q.54. What sector are you in?

Q.55. Legal status

a) Sole Trader

b) Partnership (at least 2 people)

c) Limited company (separate entity)

d) Limited liability partnership (hybrid)

Q.56. Number of employees

a) 0 b) 0-4 c) 5-9 d) more than 10

Q.57. Annual turnover

a) up to £80, 000

b) up to £250,000

c) up to £500,000

d) over £1 million

Thank you for your time and taking part in my PhD research project - it is very much appreciated!

Appendix J – Data Analysis – Trustworthiness – Checklists/process

This section provides a summary of how I evaluated my research (J.1). The TA checklist to confirm method and process for trustworthiness (J.2). A detailed step-by-step explanation on my data reduction, analysis and display process by combining multiple methods identified in Section 4.11) (J.3).

J.1 Table - How I evaluated my research – created personal checklist

I created my own personal checklist to ensure I captured all the salient points when reflecting on best practice identified in the methodology (Chapter Four).

	Philosophy, Methods & Approach	Section detail
1	Pragmatic limited realist approach – develop an account that is credible and potentially transferable, while recognising conclusions will always be tentative. Often uses *a priori* themes information by theory. Quality checks to stimulate critical thinking, specific to needs of particular study. Reflexivity/reflection in analysis is important to go beyond researcher subjectivity	4.3.1 (Table 4.1)
2	Pragmatic approach and semi-structured interview guides to "get the job done" – focused questions with this goal in mind. In Vivo responses were used primarily to limit researcher subjectivity.	4.10 & Appendix I.
3	Constant reflection during observations, interviews & document analysis on four-fold capitals, RQs and how to reach the final few was the pragmatic lens used throughout this thesis.	4.11.2 – codebook as aide memoire.
4	Case study protocol (Yin, 1994) followed by Runeson & Host (2008) checklist – design, collecting evidence, reporting.	Appendix G & H.
5	Intrinsic Case Study (Stake, 1995) – case is complex & time to analyse it is short – trade-off between naturalistic generalisations versus time taken to generalise results – important strategic choices required to organise analysis & accommodate both outcomes.	4.11
6	Initial coding structure using semi-structured interview guide format – coding framework & a priori codebook.	4.11.2 (Fig 4.6) - Appendix I & K.
7	Coding process - data reduction, data analysis, data display – following (Miles & Huberman, 1994) for process & coding (Saldana, 2015).	4.11.3 - detailed below Appendix J.3.
8	Thematic Analysis (TA) Hybrid-approach – deduction (coding to framework & *a priori* codebook) & induction (themes arising from interviews – surprises, salient points).	4.11.1 - 2
9	Coding the most salient points and prioritise the most meaningful data– intrinsic case study trade-offs (Stake, 1995).	4.11.4

10	Analytical memos – to encourage critical thinking, academic learning & reflection throughout research & data analysis (Saldana, 2015).	4.7.4 & 4.11.4
11	King & Brooks (2018) – audit trail, member checks.	4.12
12	Collins (2014), Lincoln & Guba (1985) - Credibility, reflection, reliability & validity – overall summary & audit trail.	6.10 - summary
13	Nowell et al. (2017) – thematic analysis (TA) method & process checklist to validate trustworthiness – prolonged engagement, triangulation, code book, audit trail.	Appendix J.2
14	Attride-Stirling (2001) - process & checklist - thematic network analysis (TNA) framework & concepts for data organising & visualisation technique.	4.11. (Table 4.5) – summarised in Appendix J.3

J.2 Thematic Analysis (TA) – checklist - method and process for audit trail

Reflective practice - summary for audit trail (Section 4.12). *Please note - meeting and peer debriefing removed checks were removed.*

J.2 Table - Nowell et al. (2017) TA checklist - to validate trustworthiness (p. 4)

Phases of thematic analysis	Means of establishing trustworthiness	Checklist for this Thesis
Phase 1 – familiarise yourself with the data	Prolonged engagement with data	Yes – four-year engagement & over 10 hours of interview data with Mr. G & 4.5 hours with INT8 (demand). Six-month observation engagement attending Welsh Government Rural Digital Taskforce (supply). Manual editing of 14 supply interview transcripts, 5 demand transcripts (2020), 7 microbusiness transcripts (2016) & observation field notes.
	Triangulate different data collection modes	Yes – field notes, observation, interview & secondary literature data noted & interwoven in Chapter 5 (macro-level) & Chapter 6 (micro/local level).
	Document theoretical & reflective thoughts	Yes – 3 x 150-page research journals for reflection & academic learning over 3-year period. NVivo research journal (40 pages) for daily coding analysis (see below).
	Store raw data in well-organised archives	Yes – manual & electronic storage.
	Keep records of all data field notes, transcripts & reflexive journals	Yes – manual & electronic. NVivo & computer (electronic). Manual journals (as above).
Phase 2 – generating initial codes	Research triangulation	Yes – see below (J.3) for coding process.
	Reflective journaling	Yes – NVivo research journal (40 pages) to record daily what, how & why coding & thematic network analysis is developing. Challenges of operational definitions.

	Use of coding framework	Yes – see below (J.3) – conceptual framework & *a priori* coding for capital definitions.
	Audit trail of code generation	Yes – see below (J.3). First cycle (holistic In Vivo coding) with surprise & key quote coding. Second cycle (patterned & focused) with human & social capital operational definitions. Third cycle (summary & refinement).
Phase 3 – searching for themes	Researcher triangulation	Yes – see below (J.3) – triangulation throughout observations, interviews, secondary literature.
	Diagramming to make sense of theme connections	Yes – use of quotation maps, code maps & A3 paper maps for thematic network analysis. See below (J.3) for details.
	Keep detailed notes about development & hierarchies of concepts and themes	Yes – see below (J.3) – original questionnaire structure for overall holistic & In Vivo coding (first cycle). Second cycle – organised themes for context, value of human capital, social capital & barriers/hinderances/obstacles.
Phase 4 – reviewing themes	Researcher triangulation	Yes – see below (J.3) – maintaining focus on HVS supply & demand ecosystems.
	Test for referential adequacy by returning to raw data	Yes – primary aim was to use In Vivo coding as much as possible. Key quote analysis & summaries was used as critical foundation. See below (J.3).
Phase 5 – defining & naming themes	Researcher triangulation	Yes – managing the complexity of this data was challenging but the Conceptual Framework & HVS provided the framework to organise the data across the ecosystems.
	Documentation on theme naming	Yes – using NVivo research journal & A3 code mapping. See below (J.3).
Phase 6 – producing the report	Member checking	Yes – pilot testing (Section 4.10), during interview/clarification over stranded assets (Section 5.4.1). For technical accuracy (INT1 & INT3). Interviews asked for transcripts (INT7, 12, 17 &18) for confirmation.
	Describing process of coding & analysis in sufficient details	Yes – see below (J.3).

	Thick description of context	Yes – Chapter 4/Section 4.7.1 (overview of case study area). Chapter 5 (throughout chapter for both supply & demand – observation, interview & secondary data analysis). Thick description of Splits-Ville case study area – LDCs are IT experts with two decades of experience living in final few & hard to reach area in Wales.
	Description of audit trail	Yes – data collection procedures 1-V1 (Section 4.8.1). Case study protocol (Appendix H). Case study checklist (Appendix I). Thematic Analysis checklist with process & audit trait (Appendix J.2). NVivo journal – annotations, cross referencing, coding cycles. Chapter 5 – 31 quotation maps. Chapter 6 – 26 quotation maps. In Vivo coding to *a priori* codes (Appendix K).
	Report on reasons for theoretical, methodological & analytical choices throughout the entire study	Yes – *a priori* coding & codebook is the theoretical (human & social capital), methodological (HVS connecting core assets of several stakeholders) & pragmatic analytical choices focusing on "getting the job done" (Section 4.11 & 12).

J.3 Researcher data analysis - detailed step-by-step process guide

The following section combines multiple sources and processes (Section 4.11) and summarised above in J.1 Table for reflection.

NVivo Organisation followed guide for case study report (Section 4.7.4/Fig 4.2).

1. Observation data – Taskforce, Welsh Government Event and Conferences notes (n=3).
2. Document data – PowerPoint slides, reports, videos and so forth (Tier two & three).
3. Interview data – Supply (n=14) and Demand (n=5) interviewees in 2020.

1 & 2 - OBSERVATION & SECONDARY DATA

Coding for Observation and Document (including video) data followed code framework (Section 4.12.1). Attribute, Descriptive and In Vivo coding to capture Key Quotes, Salient Points, Surprises and most meaningful data relevant to context and answering the RQs. *A priori* (or structural coding) to identify capitals and Industry 4.0 updates were always prevalent.

- For example during Observation analysis: SURPRISES in Taskforce Meetings were the introduction of the Engagement Officers to case study area and new funding opportunities during Conferences and Welsh Government meetings. All relevant in 'getting the job done' and reaching the final few.

- For example during Document/video analysis: technical YouTube videos showcased the value of human, social and environmental capital and were coded and extracted as such to answer the RQs.

EXAMPLE OF NVIVO CODING HIERARCHY - conferences

Conference observations

Name	Files	References	Created On	Created
5G overall	0	0	27/08/2021 10:54	SC
CONFERENCE KEY QUOTES	7	51	28/04/2020 16:39	SC
Consortium - Funding bids	3	8	28/04/2020 16:39	SC
Demand stimulation	3	3	28/04/2020 17:59	SC
Environmental Capital	1	2	28/04/2020 16:43	SC
Human capital - skills	5	24	28/04/2020 16:51	SC
Outcome of SFBB Cymru	2	3	28/04/2020 17:54	SC
Partnerships	3	10	28/04/2020 16:39	SC
SFBB SME Exploitation findings	2	7	28/04/2020 17:50	SC
Surprise	3	4	28/04/2020 17:52	SC

3. INTERVIEW DATA

The most detailed analysis was during the interviews which followed the summarised outline in (**Section 4.11 & 5.1.2**). It is impossible to capture every detail, but this summary provides a snapshot of how the complexity was organised and analysed (5.1.2, Fig 5.2).

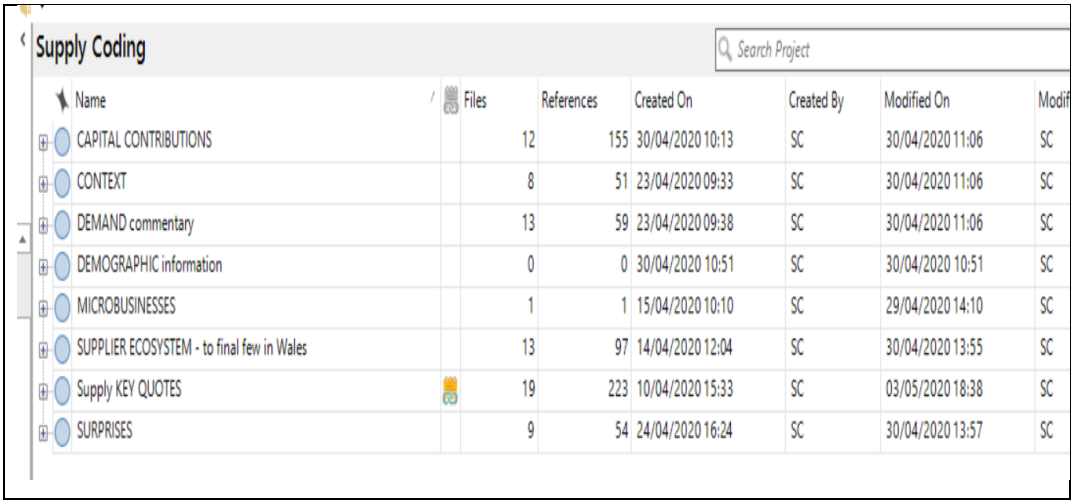
J.3 Table - OVERALL – DETAILED STEP-BY-STEP DATA ANALYSIS PROCESS

Combining Attride-Stirling TNA process guide (Section 4.11.1, Table 4.5) and Miles & Huberman (1994) data reduction, analysis & display (Section 4.11.2 - 4).

STAGE 1 - DATA REDUCTION A. Reduction & breakdown of text			
STEPS	**TA/TNA METHOD**	**PROCESS**	**EXAMPLE**
1	Familiarise myself with the data	Trint transcription manual editing – supply interviews (n=14) & 2020 demand interviews (n=5).	Prolonged engagement – as above (J.2).
2	Upload to NVivo to code material	Creating individual cases per event & interviewee.	
3	Create initial code hierarchy for both supply & demand using semi-structured interview guide's format.	Using coding framework structure – for interviews	Section 4.11.2 (Figure 4.6)
		For SUPPLY: Section 1 – Industry 4.0 & current challenges (barriers/opportunities). Section 2 – HC, SC, EC, FC. Section 3 – demographic information.	Example I.1 semi-structured interview guide – **Supply Coding Hierarchy**
		For DEMAND: Part 1 – RSCAT – Rural community Part 2 – Social capital Part 3 – Industry 4.0 Part 4 – demographic information.	Example I.2 semi-structured interview guide – **Demand Coding Hierarchy**
4	Code material - dissect text into text segments. Generating initial codes	1st cycle coding – attribute, descriptive, holistic, In Vivo, structural & simultaneous coding – answers to each interview guide question. Separate codes – SURPRISES & KEY QUOTES/salient points & adding any additional inductive categories.	
	TA hybrid-approach	DEDUCTIVE – coding to *a priori* codebook (human, social capital & so forth). INDUCTIVE – coding to emerging themes, surprises & so forth from interviews.	
5	Identify themes – TNA mapping	Using A3 paper maps to start visualising data and organising through TNA – used COLOUR CODING for analysis:	Example J.3 – Overall Supply First Cycle

		ORANGE (recoding required – options for second cycle). GREEN (unsure how-to code? Check relevance). RED (critical theme identified). BLUE (key areas for analysis). BROWN (duplicates/cross referencing)	Coding Map for initial analysis
		Re-organising NVivo to reflect summarised categories	Example J.4 – overall supply hierarchy summary

EXAMPLE J.1 – NVIVO - SUPPLY CODING HIERARCHY - OVERALL

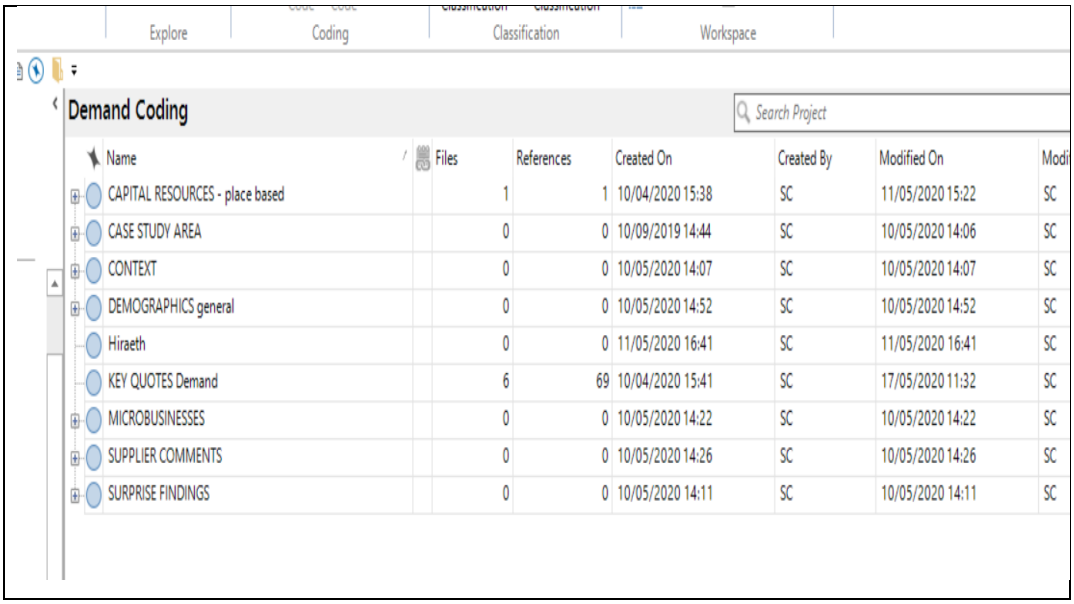


Supply Coding

Search Project

Name	Files	References	Created On	Created By	Modified On	Modif
CAPITAL CONTRIBUTIONS	12	155	30/04/2020 10:13	SC	30/04/2020 11:06	SC
CONTEXT	8	51	23/04/2020 09:33	SC	30/04/2020 11:06	SC
DEMAND commentary	13	59	23/04/2020 09:38	SC	30/04/2020 11:06	SC
DEMOGRAPHIC information	0	0	30/04/2020 10:51	SC	30/04/2020 10:51	SC
MICROBUSINESSES	1	1	15/04/2020 10:10	SC	29/04/2020 14:10	SC
SUPPLIER ECOSYSTEM - to final few in Wales	13	97	14/04/2020 12:04	SC	30/04/2020 13:55	SC
Supply KEY QUOTES	19	223	10/04/2020 15:33	SC	03/05/2020 18:38	SC
SURPRISES	9	54	24/04/2020 16:24	SC	30/04/2020 13:57	SC

EXAMPLE J.2 – NVIVO - DEMAND CODING HIERARCHY - OVERALL



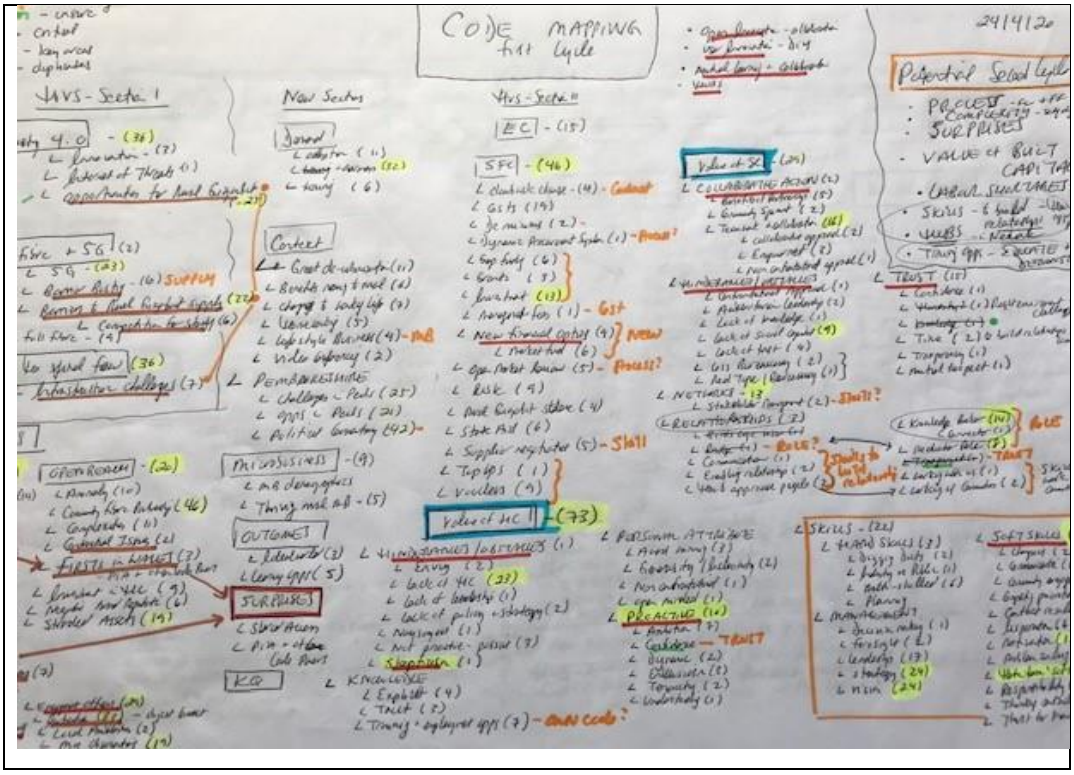
Explore Coding Classification Workspace

Demand Coding

Search Project

Name	Files	References	Created On	Created By	Modified On	Modi
CAPITAL RESOURCES - place based	1	1	10/04/2020 15:38	SC	11/05/2020 15:22	SC
CASE STUDY AREA	0	0	10/09/2019 14:44	SC	10/05/2020 14:06	SC
CONTEXT	0	0	10/05/2020 14:07	SC	10/05/2020 14:07	SC
DEMOGRAPHICS general	0	0	10/05/2020 14:52	SC	10/05/2020 14:52	SC
Hiraeth	0	0	11/05/2020 16:41	SC	11/05/2020 16:41	SC
KEY QUOTES Demand	6	69	10/04/2020 15:41	SC	17/05/2020 11:32	SC
MICROBUSINESSES	0	0	10/05/2020 14:22	SC	10/05/2020 14:22	SC
SUPPLIER COMMENTS	0	0	10/05/2020 14:26	SC	10/05/2020 14:26	SC
SURPRISE FINDINGS	0	0	10/05/2020 14:11	SC	10/05/2020 14:11	SC

EXAMPLE J.3 – A3 CODING MAP - INITIAL SUPPLY - OVERALL



1. Process for supply interview first cycle of coding *(deductive) – followed semi-structured interview guide (Appendix I.1), the code framework & a priori codebook (Section 4.11.2). For example:*

- *Section 1 – Industry 4.0 and opps/challenges (Descriptive, In Vivo, Holistic, Simultaneous, Structured coding).*
- *Section II – capital contributions - answers to human, social, environmental & financial capital (Descriptive, In Vivo, Holistic, Simultaneous, Structured).*
- *Section III – demographic information (Attribute coding).*

2. Overall A3 code map *- created to look for themes & organising patterns (above).*
Colour coding *was used to analyse results:*

- *ORANGE – recoding required – options for second cycle coding*
- *GREEN – unsure on how to code?*
- *<u>RED – critical theme identified (underlined)</u>*
- *BLUE – key areas for analysis*
- *BROWN – duplicates/cross referencing*

3. Code frequencies were highlighted in yellow *– however, after initial overview this was not a primary focus for analysis because of the individual viewpoints of multiple stakeholders – although some categories have useful frequency counts (e.g. soft skills). The focus became more on salient points & meaningful data analysis to answer the RQs.* ***Meaningful data*** *included answers to RQ1 (what capitals are required?). RQ2 (what mutual learning opportunities are there?). RQ3 (what new and innovative processes?).*

Code frequency results – not all relevant. For example: Industry 4.0 - with subcategories/themes of innovation (3), internet of threats (1), opportunities for rural gigabit (25). Categories for "full fibre & 5G" included themes: barrier busting, barriers to rural gigabit supply, competition for staff. Category for "reaching the final few" included

infrastructure challenges. (GREEN, BROWN and ORANGE notations for second cycle coding summarised these under categories such as "Context" and "Complexities").

Code frequency results – became more relevant during in-depth analysis of human & social capital (e.g. soft skills).

***4. New categories were added** (inductive coding) - outside of the Code framework (Sections I-III structure) to ensure each supply transcript THEME was captured. These included:*

- *Demand category – adoption, awareness (32) and training (6).*
- *Context category – great de-urbanisation (11), benefits moving to rural (6), changes to working life (7), homeworking (5), lifestyle business (4), Pembrokeshire – challenges in Pembs (25), opportunities in Pembs (21), political commentary (41).*
- *Microbusinesses – MB demographics, thriving rural MB (5).*
- *Outcomes – ideal world (3), learning opportunities (5)*
- *SUPPLIERS category*
    - *Altnets – altnet strategy (14), backhaul (3), INCA (4), Ofcom powers (BROWN code - CROSS REF to SURPRISES).*
    - *Openreach (20) – anomaly (10) (BROWN code – CROSS REF to SURPRISES), community fibre partnership, complexities (11), contractual issues, FIRST IN WALES, PIA and Ofcom powers (BROWN code – CROSS REF to SURPRISES), investment in HC (9), negative brand reputation (6), stranded assets (19 (cross REF to SURPRISES).*
    - *Welsh Government – DCMS, Shared Spectrum Access Scheme (BROWN code - CROSS REF TO SURPRISES), Superfast Cymru Contractual issues, <u>Taskforce – in RED</u> – new concept, best practice, inspiration, mutual learning, engagement officers, initiatives – object connect, local authorities, my observations (BROWN and ORANGE -RECODED TO FIRST IN WALES/SURPRISES).*
- *<u>SURPRISES – identified in RED</u> - First in Wales, Shared Spectrum Access, PIA and Ofcom powers, anomaly, stranded assets*
- *KEY QUOTES category – captured killer quotes/salient points to answer RQs.*

5. Section II – Capital contributions

i. ***Environmental capital** (15) – no a priori coding was required for EC (Section 4.11). For example – comments on 5G health & safety, opportunities, land, technology and so forth were captured.*

i. ***Shared financial capital** (46) – no a priori coding was required for FC (Section 4.11). Subcategories/themes included: clawback clause (4), costs (19), de minimus (2), dynamic procurement system (1), gap funding (6), grants (3), investment (13), management fees (1), <u>new financial options (9) outlined in RED</u>, market fund (6), open market review (5), risk (9), rural gigabit scheme (4), state aid (6), supplier negotiations (5), top ups (1), vouchers (9). ORANGE recoding noted to explore – CONTRACT, PROCESS, COST, NEW FUNDING, SKILLS (for potential second cycle categories/themes).*

i. ***Value of human capital** (73) – identified in BLUE as key area – a priori coding and subcategories/themes included: <u>Barriers/hinderances/obstacles</u> – <u>identified in RED</u> - envy, lack of HC, lack of leadership, lack of policy and strategy, nay-sayers, not proactive – passive, scepticism.*
    - *Knowledge category – included explicit (4), tacit (3), training and employment opportunities (7).*
    - *Personal attribute category – award winning (3), generosity/inclusivity (2), non-confrontational (1), open-minded (1). <u>Proactive (10)</u> RED – ambition (7),*

confidence (ORANGE recode for trust). Dynamic (2), enthusiasm (3), tenacity (2), understanding (1).

- *Skill category – initial subcategories/themes included*
  - *Hard Skills (3) – digging ducts, industry vs public (1), multi-skilled (6), planning.*
  - *Management skills – decision making (1), foresight (2), leadership (17), strategy (24), vision (24).*
  - *<u>Soft skills (60) in RED</u> – champions (2), communication (6), community engagement (4), competing priorities (1), conflict resolution (12), inspiration (6), motivation (15), problem solving (1), hate term 'soft skill' (4), responsibility (9), thinking outside box (1), thirst for knowledge (1).*
  - *Note – second and third cycle coding combined words such as inspiration and motivation.*

iv. ***Value of social capital*** *(29) – identified in BLUE as key area - a priori coding & subcategories/themes included:*

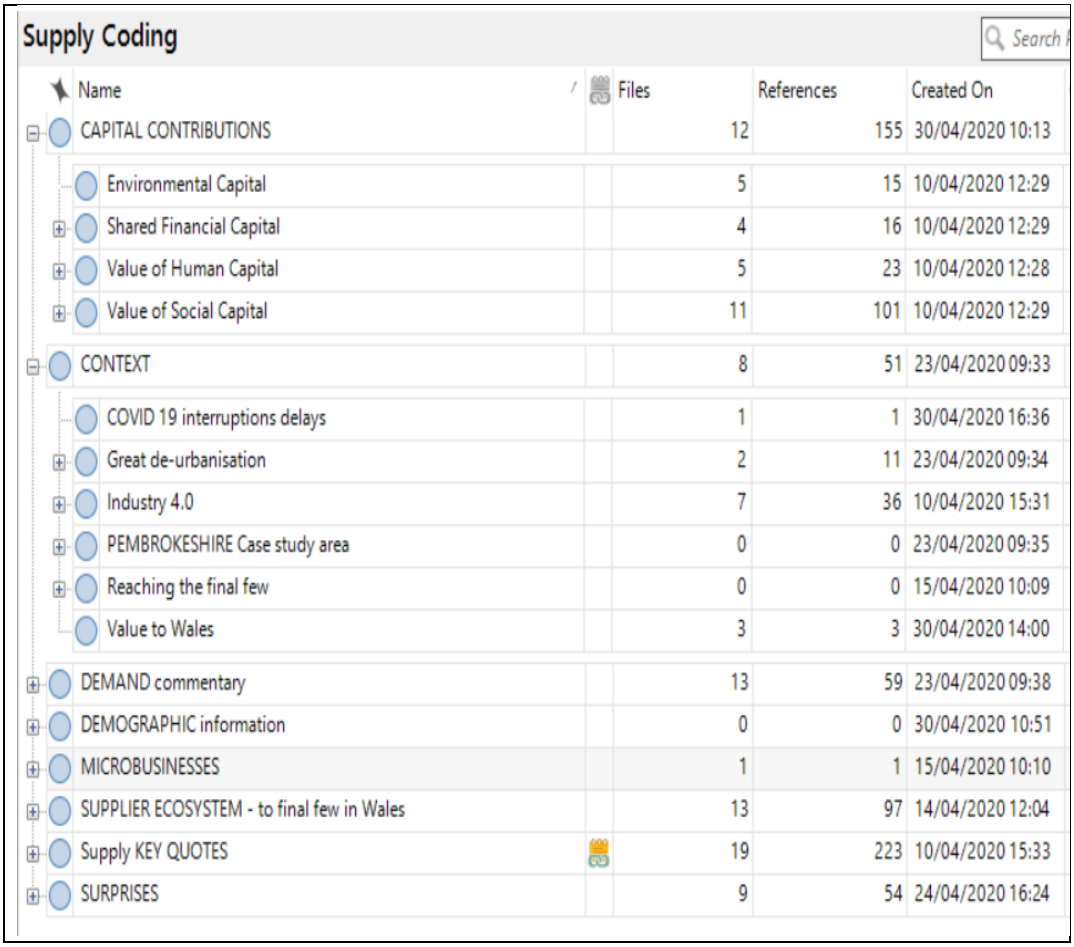
- *Collaborative action (2) – benefits of partnership (5), community spirit (2), teamwork & collaboration (16), collaborative approach (2), empowerment (3), non-confrontational approach (1).*
- *Barriers/hinderances/obstacles – identified in red as critical – confrontational approach (1), authoritarian leadership (2), lack of knowledge (1), lack of social capital (9), lack of trust (4), less bureaucracy (2), red tape/bureaucracy (1).*
- *<u>Trust in RED</u> – confidence (1), right environment to challenge (1), time to build relationships and knowledge (2), transparency (1), mutual respect (1).*
- *Networks – stakeholder management (ORANGE recode to SKILL?).*
- *Relationships (7) – birds eye view (1), bridge (ORANGE recode to ROLE?), communication (1), enabling relationship (2), how to approach people (ORANGE recode skills to SKILLS to build relationship?), knowledge broker (14), connector (1), mediator role (8) (ORANGE recode to ROLE?), transparent (1) (ORANGE recode to trust?), working with us (1), working with communities (2) (ORANGE recode SKILLS to work with communities?).*
- *Note – second/third cycle concepts identified in ORANGE.*

*6. **Potential Second Cycle coding was identified** – for example PROCESS, COMPLEXITY, SURPRISES, LABOUR SHORTAGES, SKILLS (to build relationships), ROLES, HUBS (in network), EDUCATE & DEMONSTRATE (training opportunities).*

*7. **Red highlights to capture critical thinking** – to identify key areas regarding potential intervention areas or patterns - open innovation (e.g. collaboration), user innovation (e.g. DIY or do it yourself), mutual learning and collaboration (e.g., hubs).*

*8. **Overall code mapping analysis** – provided a snapshot of what the supply participants were saying across Welsh Government, Local Authority, Commercial & Altnet suppliers.*

EXAMPLE J.4 - NVIVO CODING ORGANISATION – SUPPLY HIERARCHY



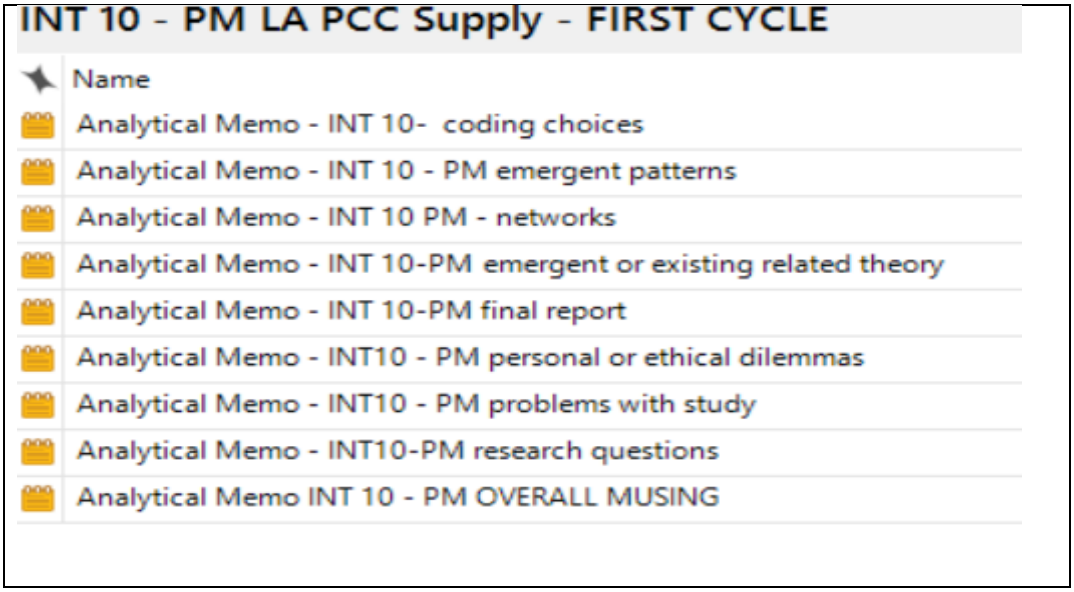
Supply Coding

Name	Files	References	Created On
CAPITAL CONTRIBUTIONS	12	155	30/04/2020 10:13
Environmental Capital	5	15	10/04/2020 12:29
Shared Financial Capital	4	16	10/04/2020 12:29
Value of Human Capital	5	23	10/04/2020 12:28
Value of Social Capital	11	101	10/04/2020 12:29
CONTEXT	8	51	23/04/2020 09:33
COVID 19 interruptions delays	1	1	30/04/2020 16:36
Great de-urbanisation	2	11	23/04/2020 09:34
Industry 4.0	7	36	10/04/2020 15:31
PEMBROKESHIRE Case study area	0	0	23/04/2020 09:35
Reaching the final few	0	0	15/04/2020 10:09
Value to Wales	3	3	30/04/2020 14:00
DEMAND commentary	13	59	23/04/2020 09:38
DEMOGRAPHIC information	0	0	30/04/2020 10:51
MICROBUSINESSES	1	1	15/04/2020 10:10
SUPPLIER ECOSYSTEM - to final few in Wales	13	97	14/04/2020 12:04
Supply KEY QUOTES	19	223	10/04/2020 15:33
SURPRISES	9	54	24/04/2020 16:24

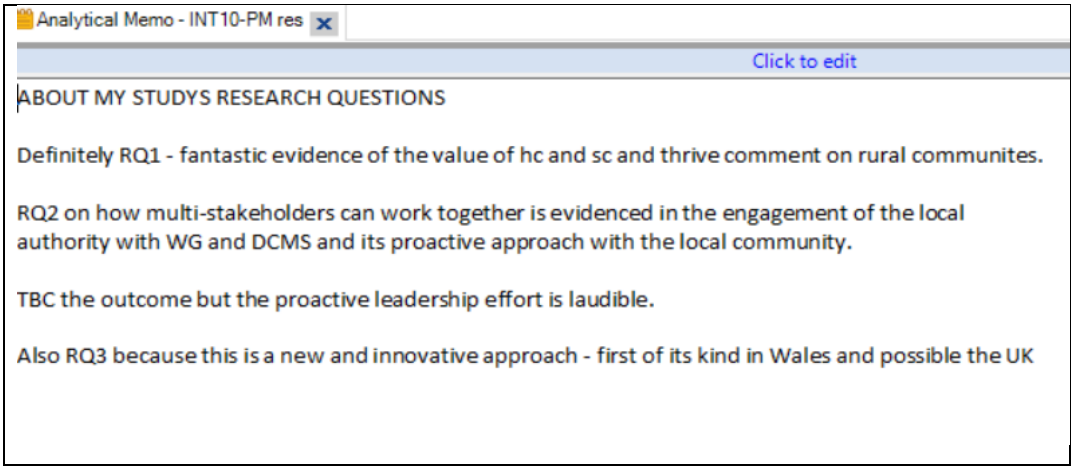
STAGE 2- DATA ANALYSIS Reflection – analytical memos, patterns & salient/most meaningful data (Section 4.11.4, Table 4.7)			
STEPS	**PROCESS**	**ANALYTICAL GUIDE**	**DETAIL/EXAMPLE**
6	Process of Analysis – **writing analytical memos for each interviewee.**	Reflection process – memo questions (Section 4.11, Table 4.7). Supply Interviewees – 14 Demand Interviewees (2020) - 5	See NVivo Memo Examples J.5 – J.8 – Overall, RQs, Code weaving, Emergent Patterns
		SUPPLY INT10 – PCC	9 MEMOS
		SUPPLY INT17 – LA EO	9
		SUPPLY IN12 - WG	6
		SUPPLY INT13 - CEO	8
		SUPPLY INT14 - WG	6
		SUPPLY INT15 - WG	11
		SUPPLY INT16 – OR	10
		SUPPLY INT18 – OR	20
		SUPPLY INT3 - OR	11
		SUPPLY INT4 – LA	7
		SUPPLY INT5 – PCC LA	10*

		SUPPLY INT6 – PCC LA	*combined INT5,6,7
		SUPPLY INT7 – PCC LA	*combined INT5,6,7
		SUPPLY INT9 – CEO	8
		SUPPLY – KEY QUOTES	SUMMARY ANALYSIS of 14 supply interviews – key quotes, concepts, findings
		TOTAL – SUPPLY INTERVIEWS	**14**
		TOTAL – SUPPLY INT MEMOS	**129** analytic memos – used to create quotation maps for Chapter 5. Coding maps for Chapter 6. Integrated analysis for Chapter 7.
		DEMAND INT1 – MR. G	Findings used for case study background, context, MB Report, RSCAT analysis (Chapter 4 & 5).
		DEMAND INT8 – LDC SV-B	11 MEMOS
		DEMAND INT11 – WARD	Key quotes/quotation map
		DEMAND INT17 – MB	Key quotes/quotation map
		DEMAND INT20 - NFU	Key quotes/quotation map
		TOTAL DEMAND INT	**5** – Vignettes used as best way to express data

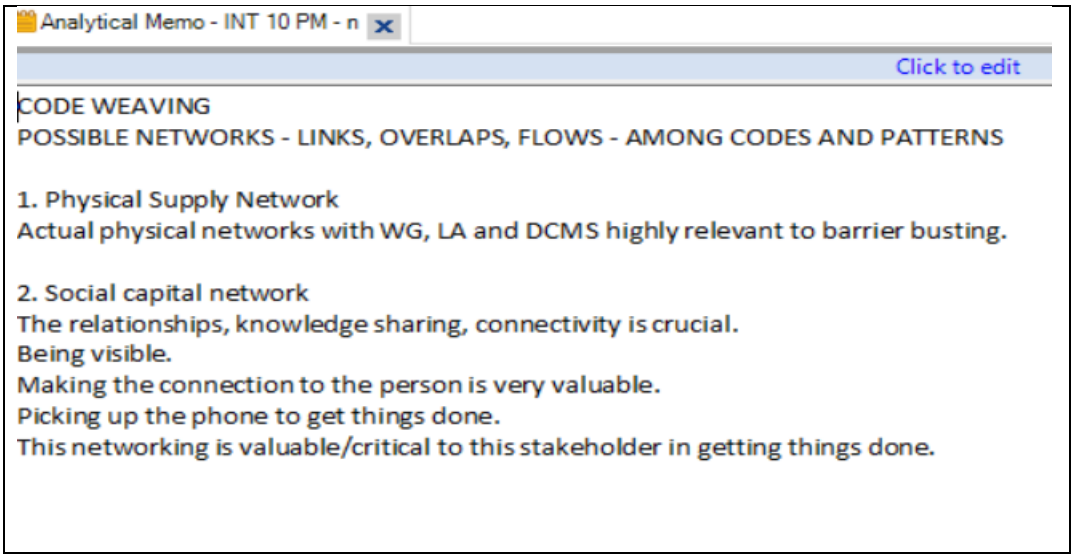
EXAMPLE J.5 - ANALYTICAL MEMO – INT10 – OVERALL STRUCTURE



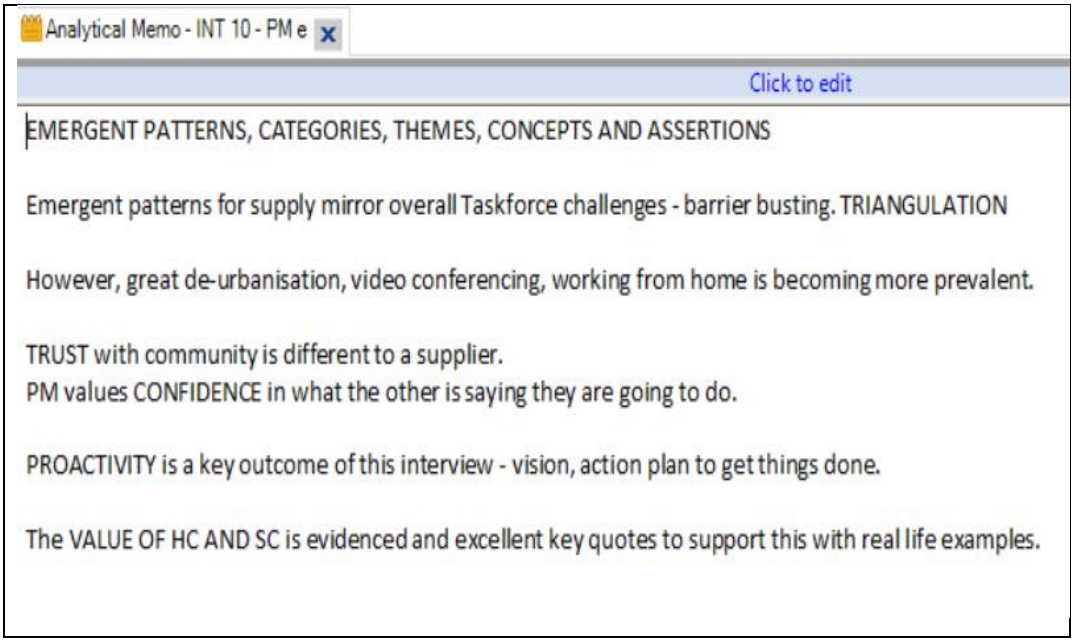
EXAMPLE J.6 - ANALYTICAL MEMO - INT10 - RQS



EXAMPLE J.7 - ANALYTICAL MEMO- INT10 - CODEWEAVING



EXAMPLE J.8 - ANALYTICAL MEMO - INT10 – EMERGENT PATTERNS

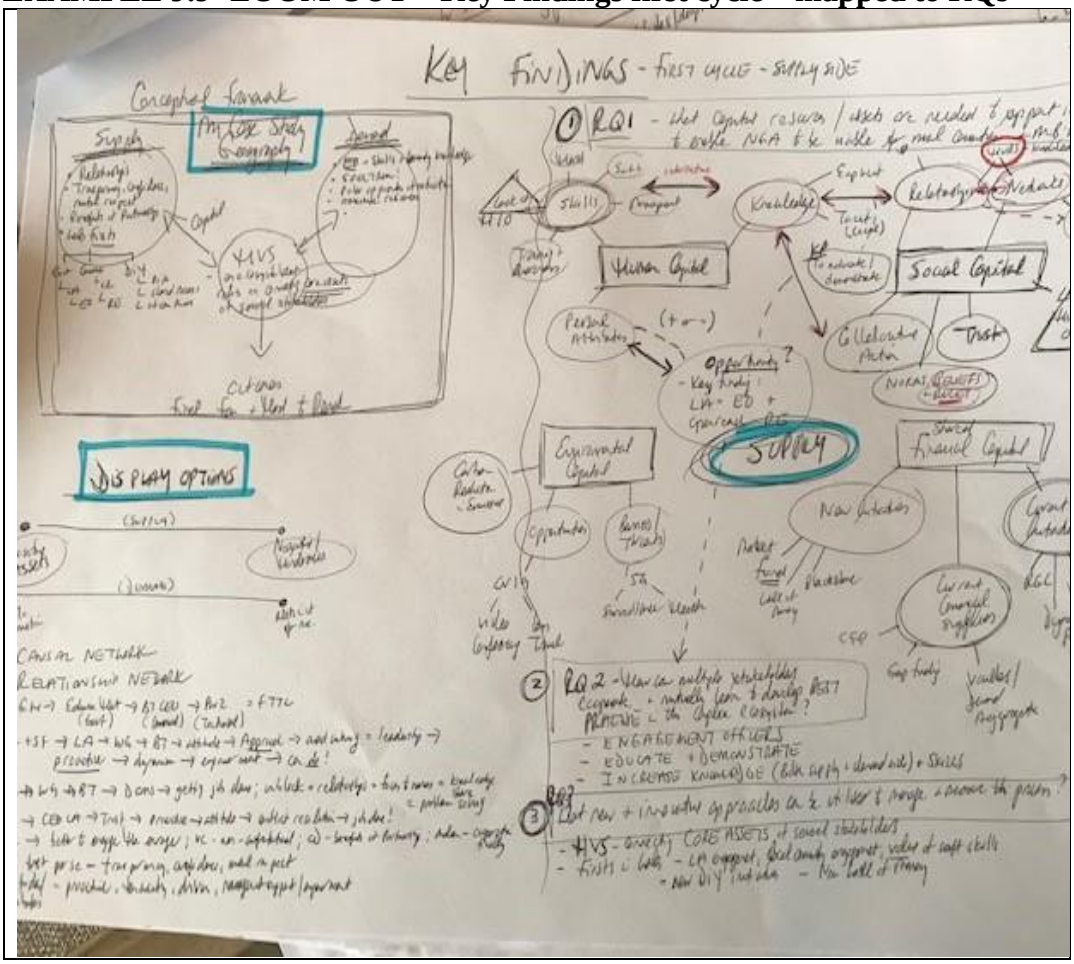


STAGE 2 - DATA ANALYSIS/EXTRACTION C. Exploration of text & integration (Section 4.11.1, Table 4.5)			
STEPS	**TA/TNA METHOD**	**PROCESS**	**EXAMPLE**
7 - Describe the network	TNA mapping but in reverse order	Deductive a priori coding provided some of the GLOBAL themes & ORGANISING themes.	Human capital (global theme). The organising themes (e.g. skills, knowledge, personal attributes). Basic themes (e.g. participant answers to questions).
	Bias check	As far as this researcher was able, the In Vivo coding was used to reflect the participants answers to the RQs	
	Zoom in/out analysis	ZOOM IN – focusing on details of one category, theme or area to map. ZOOM OUT – to pull back from data and map bigger picture or overview to analyse RQs	See Examples below – J.9 – J.20 - alternating between detailed maps & bigger picture analysis
	First TNA map to focus on most salient areas	A3 Map after first cycle to focus on KEY FINDINGS – mapped to RQ1, 2 & 3 and to focus on CONTEXT, HUMAN & SOCIAL CAPITAL – most relevant focus as theoretical underpinning	Example J.9 – ZOOM OUT - A3 Key Findings Map to RQs
	Second cycle coding	Human & social capital	Example J.10 – ZOOM OUT – focus on key areas HC & SC – second cycle coding
	Second cycle coding	Human capital	Example J.11 – ZOOM IN – HC only – second cycle
	Second cycle coding	Social capital	Example J.12 – ZOOM IN – SC only – second cycle
		Outlining and describing the supply ecosystem (network based) & the demand ecosystem (place based)	Example J.13 – ZOOM OUT – TNA overall

8 - Explore the network	**Operational definitions played key role in organising TNA**	This was the most difficult part of the analysis – attempting to pay close attention to the nuances in wording and context. For example – Human Capital – global theme Skills – organising theme Leadership – basic theme People or soft skills – basic theme.	Example J.14 – ZOOM IN – HC productivity – operational definitions.
	Bias check	Predominantly In Vivo answers to question were used to create the code books for **human capital & social capital**	Appendix K.1 (human capital) & K.2 (social capital)
	3RD cycle coding – refining, summarising, combining under operational definitions	For example – leadership can be defined as a 'trait' or 'behaviour' or 'characteristic'. However, the operational definition for skill is a particular 'ability'. Leadership could have been coded as a personal attribute (characteristic). But in the context of this study and responses from participants, it was coded as a skill or 'ability' to get things done through vision, strategy, empowerment.	Henceforth, the refined coding was analysed according to the operational definitions but within the context of the study/answers.
	3rd cycle coding - HC – answers to question and observations	For example – 'proactivity' was observed by this researcher during Taskforce & In Vivo coding.	Triangulation of observation data & coding results – PROACTIVE (organising/global CSF theme).
		Social capital collective action - summary	Example J.15 – ZOOM IN – SC collective action – operational definitions

	3rd cycle coding – SC – very challenging	Social capital was difficult to organise, but operational definitions were key.	For example – 'communication' fits in 'network' but I have in 'relationship'. Moved 'communication' to network because of operational definition. However, 'approach' is a tie to communication. 'Approaches to relationship' & 'Approaches to networks/working together & sharing information' better reflected social capital. Moved 'communication' to human capital/skills. This was a painstaking process to pull apart the participant meaning/context & operational definitions. A lot of cross-over between relationship and networks but close attention to definitions helped clean this up – creating coding mind maps to organise helped clarify/organise this process (see Chapter 6).
9 - Integration – interpret patterns	Potential intervention areas, surprises in both ecosystems	What are the key patterns?	Example J.16 – Most salient patterns - supply
		What are most salient points, surprises, potential interventions?	Example J.17 – mapping Key Quote summaries to identify patterns
		Integration of supply ecosystem	Example J.18 – Integration – 3 PARTS – supply ecosystem
		Integration of demand ecosystem	Example J.19 – DEMAND using VIGNETTES
		Overall analysis – refining storyline to date	Example J.20 – ZOOM OUT – Storyline to date – Reflection

EXAMPLE J.9- ZOOM OUT – Key Findings first cycle – mapped to RQs



1. First TNA MAP to focus on Key Findings/Key Areas – first cycle coding supply –Human & social capital.

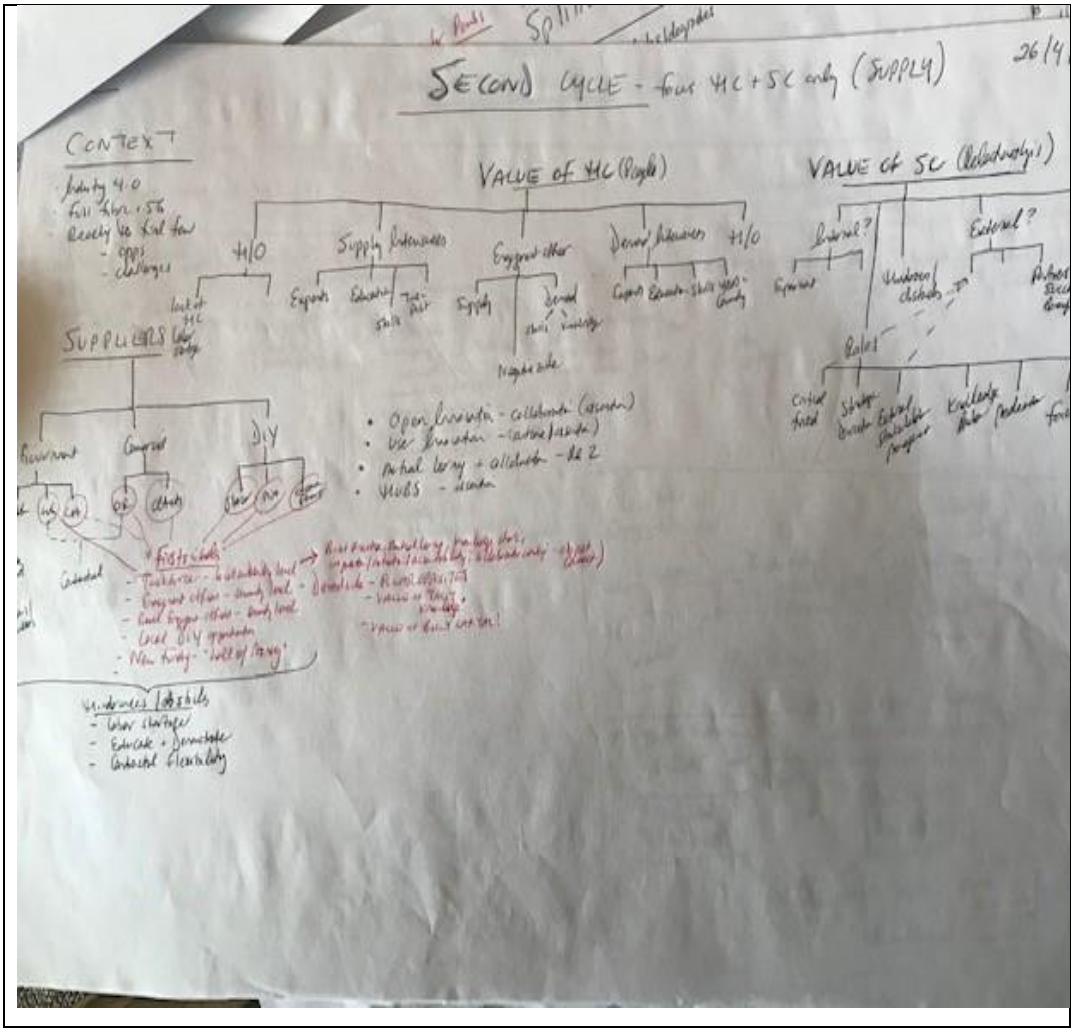
- *Mapping outcomes to RQ1 – what capital resources/assets are required to support infrastructure to enable NGA to be viable for rural communities and MBs? Used TNA structure to map HUMAN CAPITAL (global theme), SKILLS/KNOWLEDGE/PERSONAL ATTRIBUTES (organising themes) and coding results to each organising theme (basic themes).*

- *By mapping each RQ and TNA framework - overlaps and connections between HC & SC were identified. For example, KNOWLEDGE (HC – explicit and tacit/local knowledge) and RELATIONSHIPS and NETWORKS (SC – Hubs as knowledge brokers).*

- *RQ2 – how can multiple stakeholders cooperate and mutually learn to develop BEST PRACTICE in the complex ecosystem? The TNA map identified Engagement Officers, Educate & demonstrate, Increase Knowledge (both supply and demand sides) and Skills.*

- *RQ3 – what new innovative approaches can be identified to manage and measure this process? The TNA map identified HVS to manage the COMPLEXITY of several stakeholders in two ecosystems. And Surprises - FIRST IN WALES – local authority & community engagement, value of soft skills, new DIY initiatives, new funding opportunities (e.g. wall of money).*

EXAMPLE J.10 - ZOOM OUT – Second cycle – focus on HC & SC only



1. Simplified categories for organisation – overall sketch – ZOOM OUT

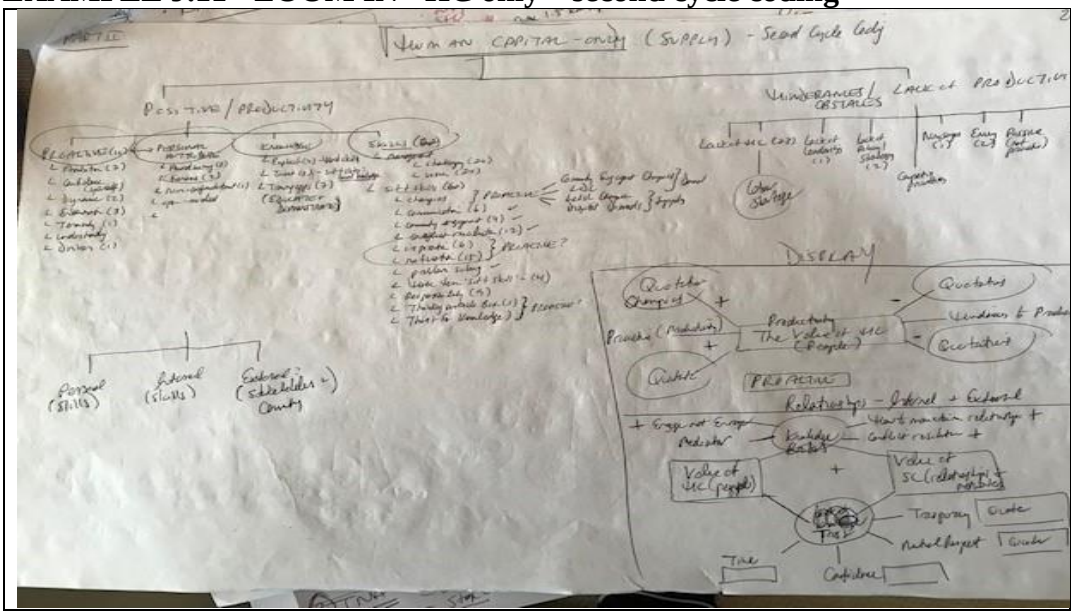
- *CONTEXT – Industry 4.0, Full Fibre & 5G, Reaching the final few – opportunities & challenges – highlighting SURPRISES "First in Wales" initiatives in RED.*

- *SUPPLIERS – Government, Commercial, DIY – start of mapping & organising the SUPPLIER ECOSYSTEM and FIRST IN WALES initiatives (Chapter 5, Section 5.11)*

- *VALUE OF HUMAN CAPITAL (People) – supply interviews, engagement officers, demand interviews, hinderances.*

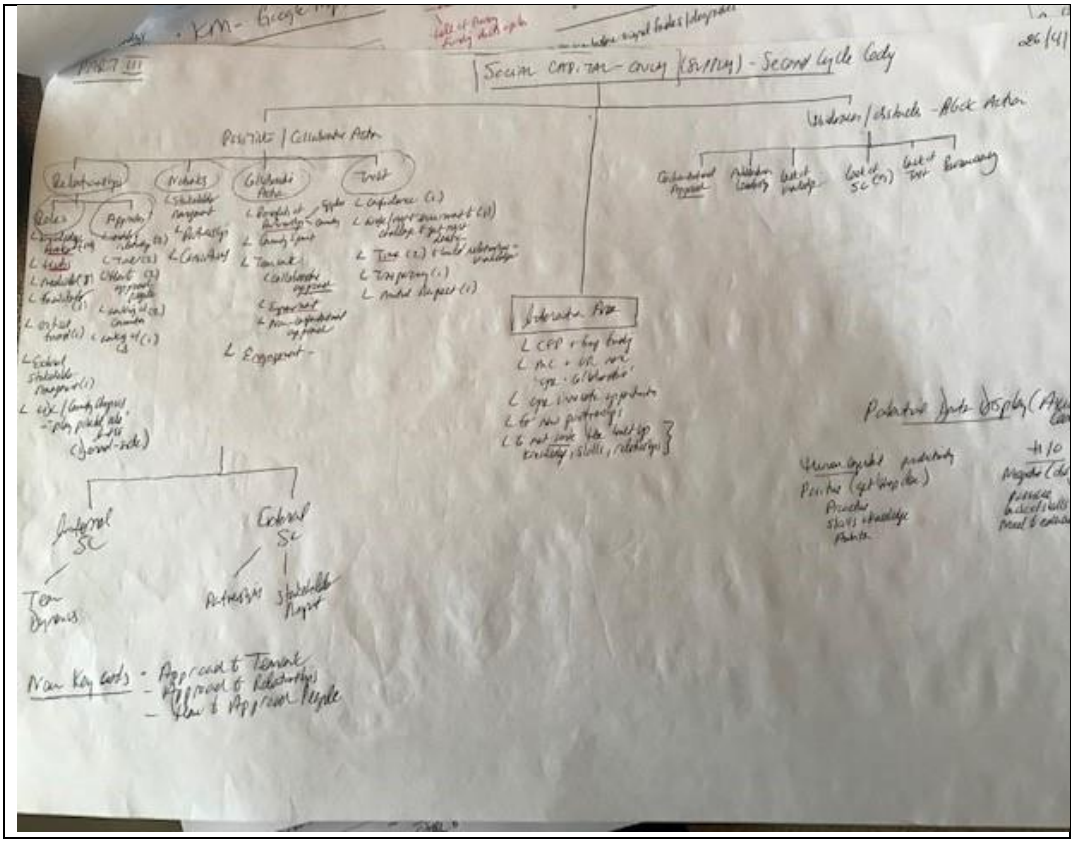
- *VALUE OF SOCIAL CAPITAL (Relationships) – internal, external, roles, hinderances*

EXAMPLE J.11 - ZOOM IN - HC only – second cycle coding



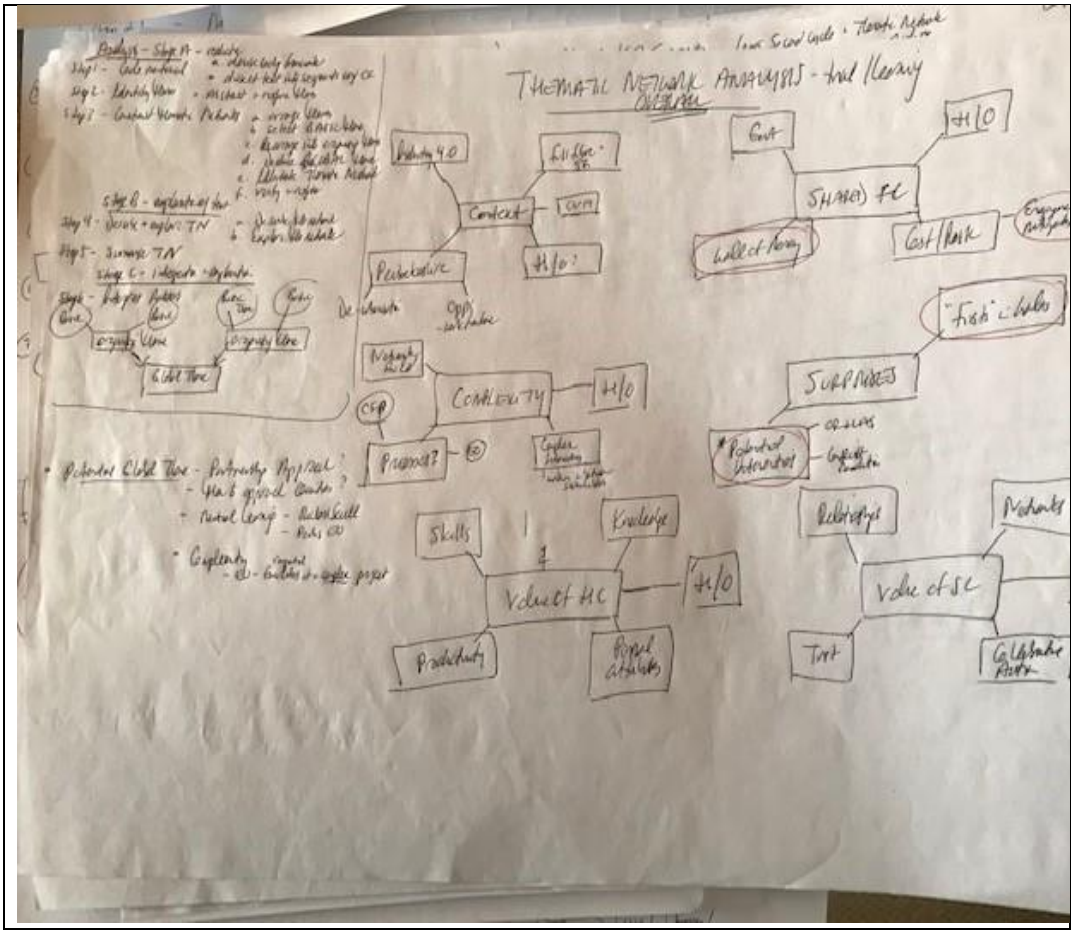
1. Second cycle coding - ZOOM IN – to details
2. The start of organisation into "Positive/Productivity" & "Barriers/Hinderances/Obstacles to Productivity"
3. Mapped out the details of SKILLS, KNOWLEDGE, PERSONAL ATTRIBUTES & identified PROACTIVE as a key global CSF theme as positive/productivity response in interviews and observations.
4. SKILLS – was a challenging category to reduce – OPERATIONAL DEFINITIONS will play an important role in coding these and separating from SOCIAL CAPITAL.

EXAMPLE J.12 - ZOOM IN – SC capital only – second cycle coding



1. Second cycle coding - ZOOM IN – to details
2. The start of organisation into "Positive/Collective Action" & "Barriers/Hinderances/Obstacles to Collective Action"
3. Mapped out details of TRUST, RELATIONSHIP, NETWORKS, COLLABORATIVE ACTION.
4. RELATIONSHIP – broken into two subcategories/themes – ROLES & APPROACHES. This is where the detailed analysis and OPERATIONAL DEFINITIONS played critical role to organise these findings.
5. NEW KEY WORDS/CATEGORIES – ***Approach*** *to teamwork, approach to relationships, how to approach people.*
6. POTENTIAL INTERVENTION AREA – this is the first time to explore interventions areas. For example, Community Fibre Partnership and gap funding. Openreach more 'open and collaborative'. Open Innovation opportunities, for partnerships, to not waste the accumulated knowledge, skills and relationships.
7. POTENTIAL DATA DISPLAYS – starting to think about how to present the data? Axial coding displays – positive and negative (hinderances)?

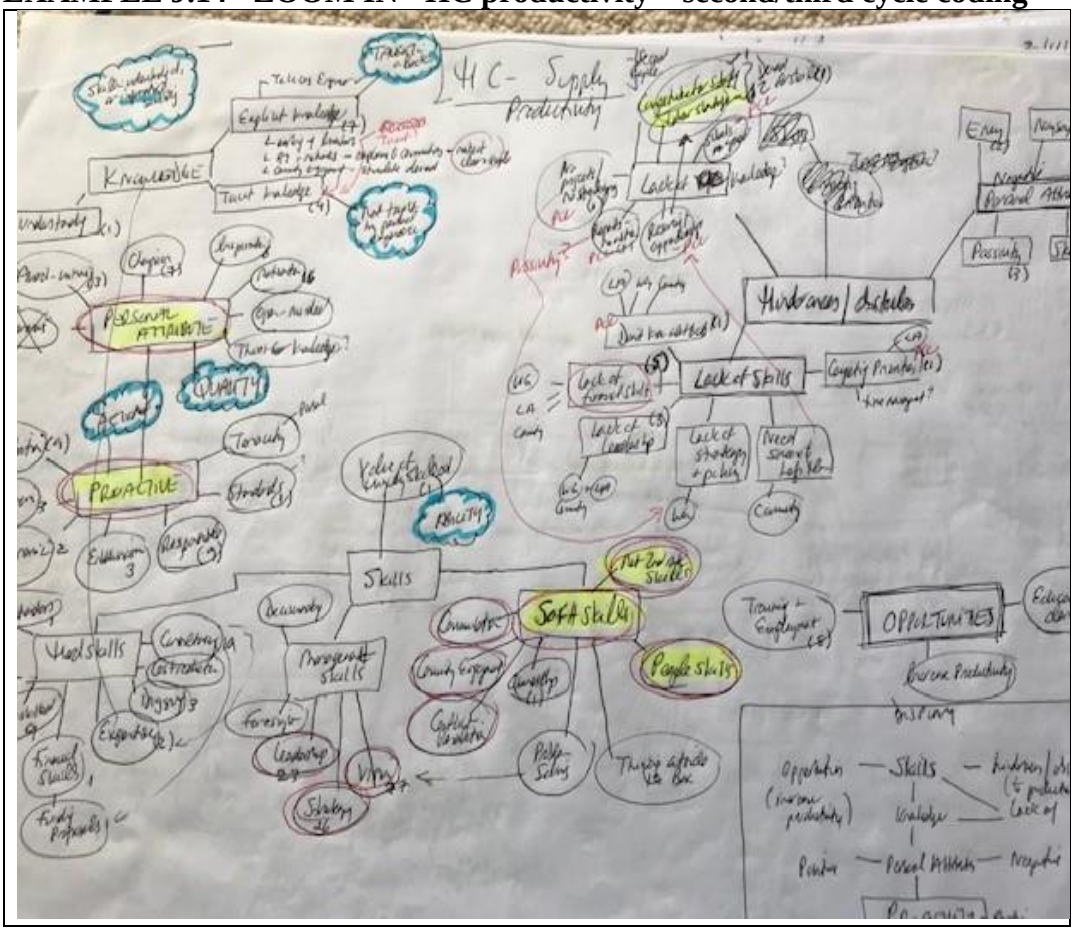
EXAMPLE J.13 - ZOOM OUT – Thematic Network Analysis – overall



1. ZOOM OUT again – to get an overall analysis of each GLOBAL THEME.
2. CONTEXT (global theme) – Industry 4.0 (organising theme), full fibre & 5G (organising theme), Pembrokeshire (organising theme), Hinderances? (organising theme), COVID19 (organising theme).
3. COMPLEXITY (global theme) – network build (organising theme), processes? (organising theme), complex interaction? (between stakeholders), Hinderances? (organising theme).

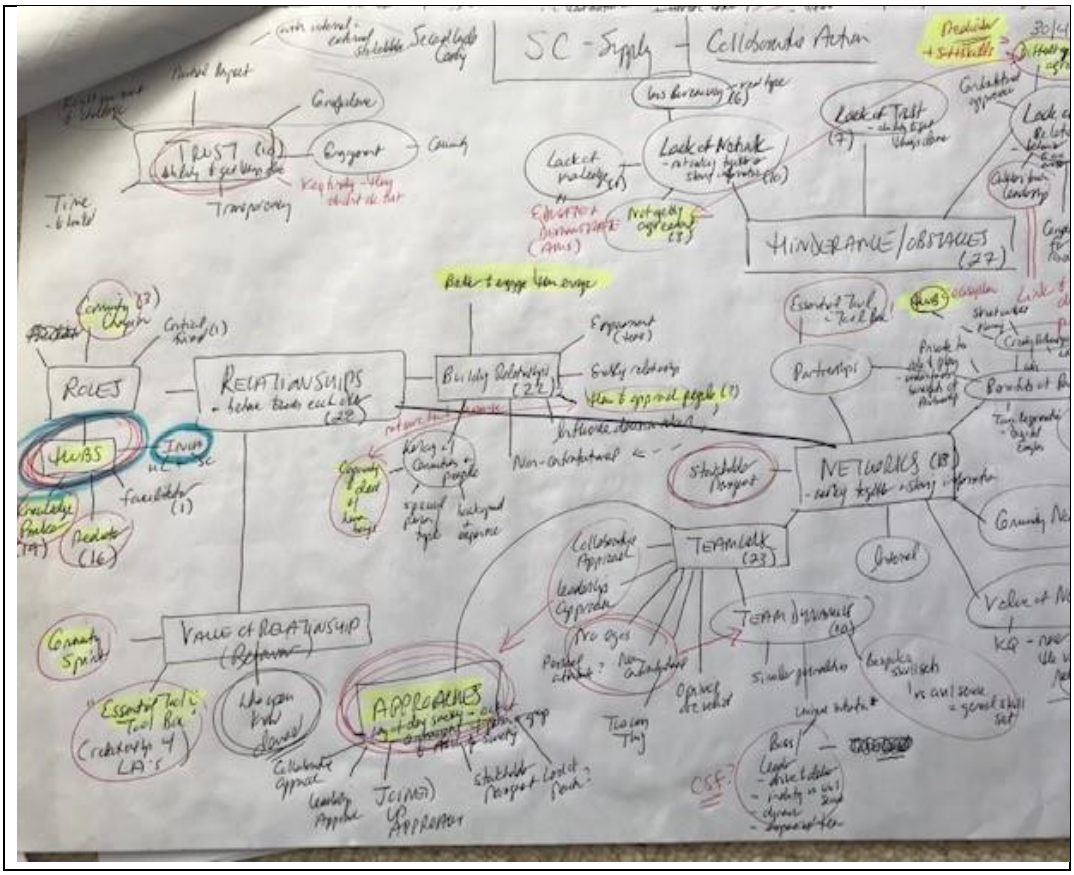
4. SHARED FINANCIAL CAPITAL (global theme) – Government (organising theme), Wall of Money? (organising theme), Cost/risk? (organising theme), Hinderances? (organising theme).
5. SURPRISES (global theme) – First in Wales (organising theme), Potential Interventions (organising theme). Potential Openreach/local authority, conflict resolution.
6. VALUE OF HUMAN CAPITAL (global theme) – skills (organising theme), knowledge (organising theme), personal attributes (organising theme), productivity (organising theme), hinderances (organising theme).
7. VALUE OF SOCIAL CAPITAL (global theme) – relationships (OT), networks (OT), trust (OT), collaborative action (OT), hinderances (OT).

EXAMPLE J.14 - ZOOM IN - HC productivity – second/third cycle coding



1. ZOOM IN – map details of human capital
2. OPERATIONAL DEFINITIONS* – *MOST DIFFICULT PART!
*3. KNOWLEDGE (global theme) – **understanding** of or **information about***
4. EXPLICIT KNOWLEDGE (organising theme) – taught in a book
5. TACIT KNOWLEDGE (organising) – not taught, by personal experience
*6. PERSONAL ATTRIBUTE (global) – **quality** or **characteristic***
7. PROACTIVE (organising/global) – taking action
*8. SKILLS (global) – particular **ability***
9. SOFT SKILLS or PEOPLE SKILLS (organising)
*10. COMMUNICATION (basic theme) – **process of sharing information**, especially when increase understanding between people or groups.*
11. OPPORTUNITIES (organising) – training and employment (8), educate & demonstrate (8)
12. DEVELOPMENT OF HUMAN CAPITAL CODEBOOK refinement – Appendix K

EXAMPLE J.15 - ZOOM IN – SC collective action – second/third cycle



1. ZOOM IN – details of social capital

2. OPERATIONAL DEFINITIONS – MOST DIFFICULT PART!

*3. RELATIONSHIPS (global theme) – **behave** towards each other*

4. ROLES (organising theme) – community champion (3), critical friend (1)

5. HUBS (organising theme) – knowledge broker (19), mediator (16), facilitator (1)

6. BUILDING RELATIONSHIPS (organising theme) – better to engage than enrage, empowerment, enabling relationship, how to approach people, non-confrontational, working with communities and people – special type of person, background & experience, capacity to deal with human beings.

*7. VALUE OF RELATIONSHIP (organising theme) **– behaviour –** Community Spirit, 'essential tool in toolbox' (relationship with local authorities), who you know*

*8. NETWORKS (global theme) – **working together & sharing information***

9. BENEFIT OF PARTNERSHIPS (organising theme) – community engagement

10. TEAMWORK (organising theme) – collaborative approach, leadership approach

*11. APPROACHES (new sub-theme to teamwork) – way of doing something – **act of communication** with person or group; ask for something*

- *COLLABORATIVE APPROACH*
- *LEADERSHIP APPROACH*
- *JOINED UP APPROACH*
- *STAKEHOLDER MANAGEMENT*

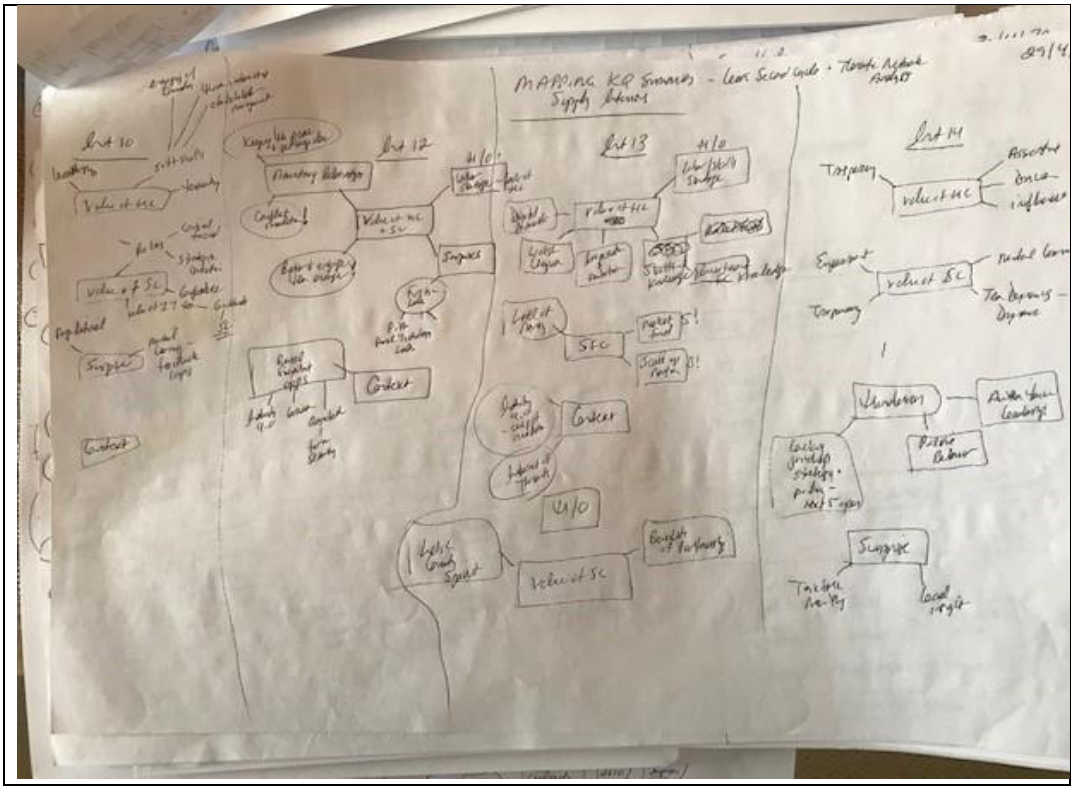
12. DEVELOPMENT OF SOCIAL CAPITAL CODEBOOK refinement – Appendix K

EXAMPLE J.16 - Most Salient Patterns – supply

Most SALIENT PATTERNS CATEGORIES
Name
PATTERN - labour shortage
PATTERN - link Altnet and WG funding
PATTERN - local authorities as key HUB
PATTERN - mutual learning feedback loops
PATTERN - opportunity for Wales - social cohesion
PATTERN - value of mediator and knowledge brokers
PATTERN - word of mouth - social capital
PATTERN CODE - creating networks and relationships
PATTERN CODE - not working together need MEDIATOR
PATTERN CODE - team dynamics
PATTERN key CONCEPT emerging APPROACHES

1. Analytical memos & annotations for cross referencing – identify most salient pattern categories/coding.

EXAMPLE J.17- INTEGRATION - mapping Key Quote summaries

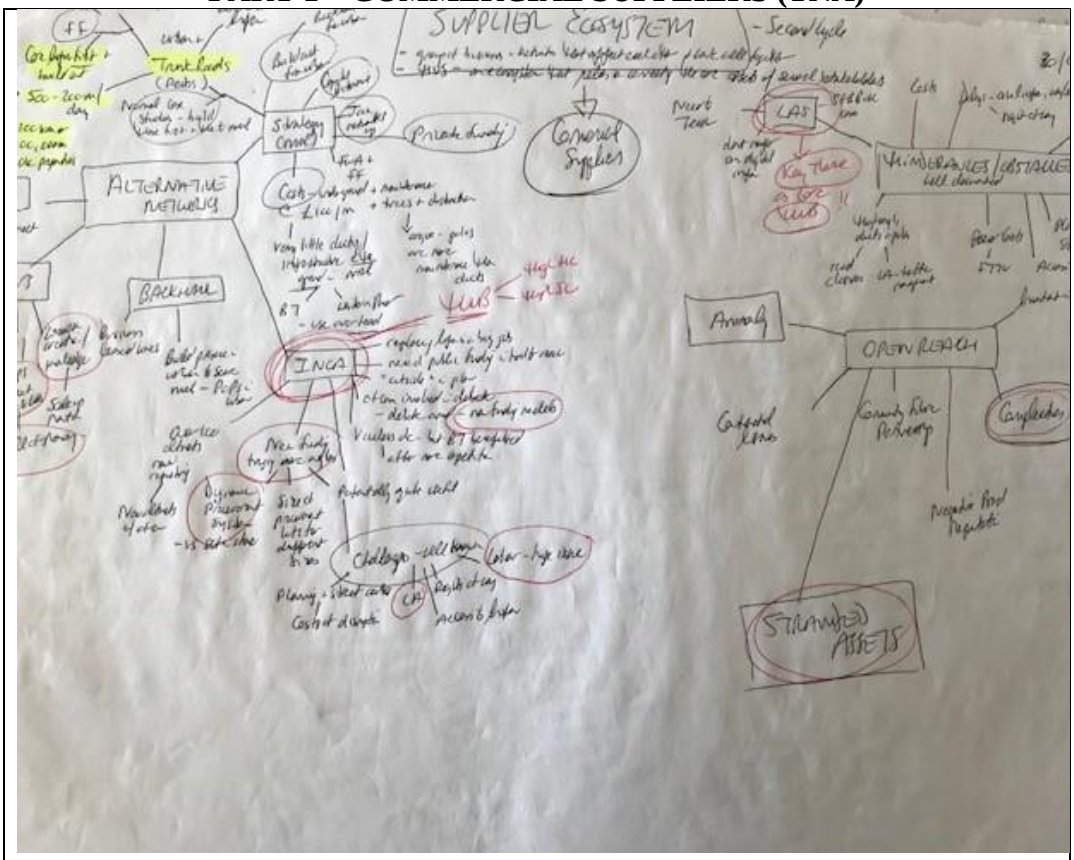


1. Using TNA structure to map KQ summaries for INT 10 (PCC leader), INT12 (WG), INT13 (CEO), INT14 (WG) – to see how the themes relate to one another & identify patterns.
2. Using GLOBAL THEMES – VALUE OF HC, VALUE OF SC, SURPRISE, CONTEXT categories to map outputs.
3. This process helped ZOOM OUT and see how the report and analysis might be shaped & any cross-referencing, triangulation, salient points interact.

EXAMPLE J.18 - INTEGRATION – Supplier ecosystem - analysis

- Ecosystem – group of businesses and activities that affect each other and work well together.
- HVS – an ecosystem that relies on connecting the core assets of several stakeholders.
- **Mapped in 3 Parts**:
- Part 1 – COMMERCIAL SUPPLIERS.
- Part 2 – SURPRISES, FIRST IN WALES, POTENTIAL INTERVENTION AREAS.
  Part 3 – UK, WELSH GOVERNMENT, LOCAL AUTHORITIES.
- INTEGRATION PROCESS – mapping key stakeholders in ecosystem – using KEY QUOTES, context, surprises & complexity coding for analysis.

PART 1 – COMMERCIAL SUPPLIERS (TNA)

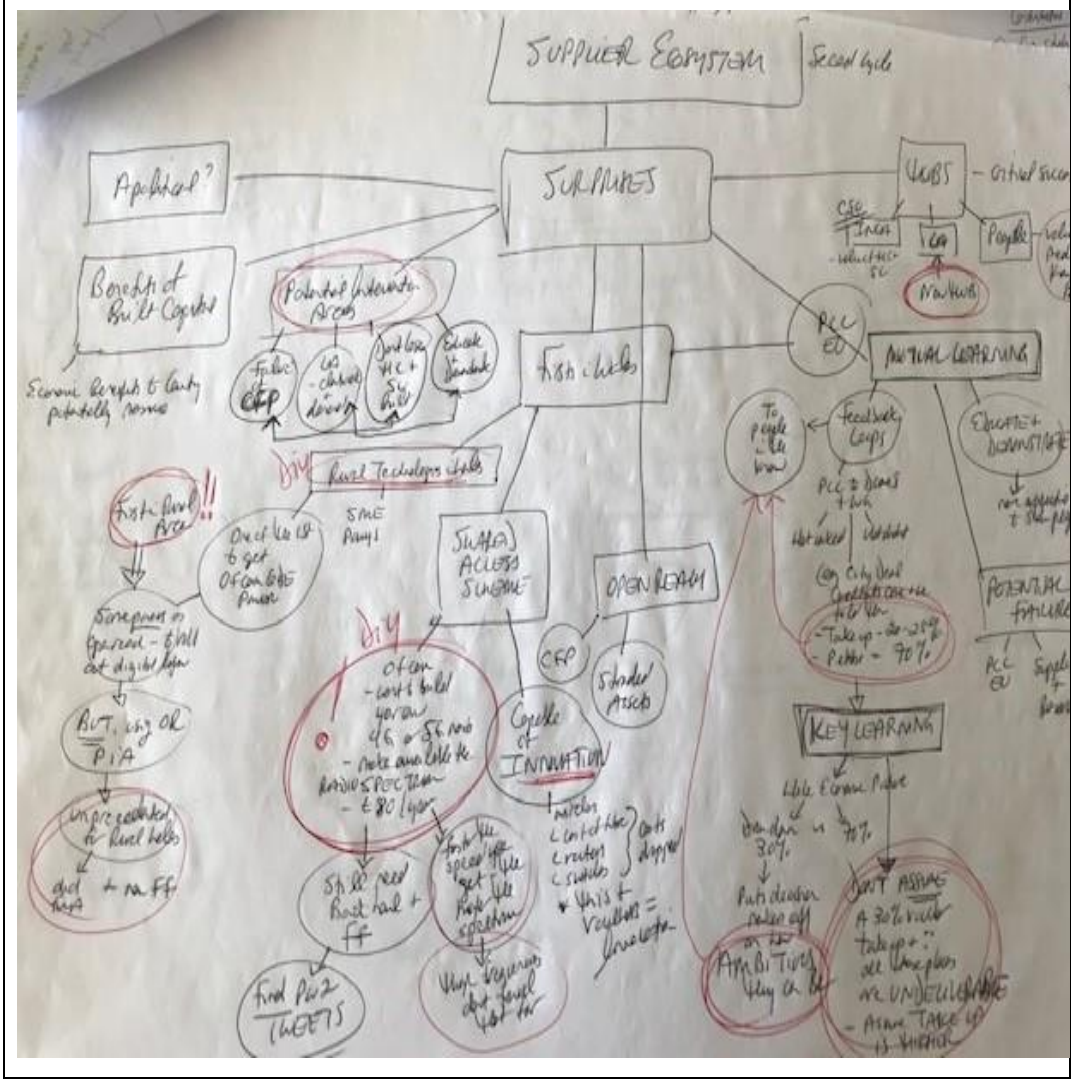


1. ALTERNATIVE NETWORKS (global theme) – INCA (organising theme), New Funding (organising theme), Strategy (organising theme)

2. OPENREACH (global theme) – complexities (organising theme), community fibre partnerships (basic theme), anomaly (surprise/basic theme), stranded assets (surprise/basic theme).

3. BARRIERS/HINDERANCES/OBSTACLES (global theme) – local authorities (key theme/core hub), labour (basic theme), delays/costs (basic theme).

PART 2 – SURPRISES, FIRST IN WALES, INTERVENTIONS - analysis



1. SURPRISES (global theme) – identified during interview coding, now mapped for analysis.

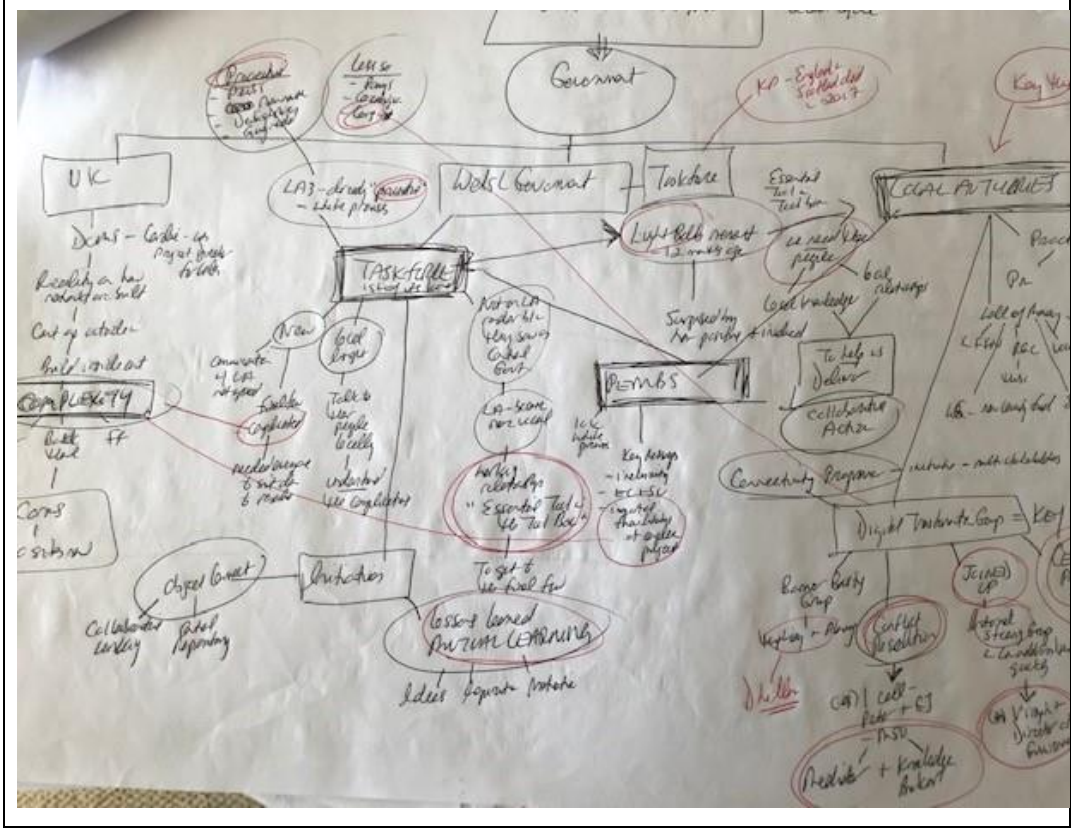
2. POTENTIAL INTERVENTION AREAS (organising theme) – failure of Community Fibre Partnership, Local Authority clawback, don't lose/squander built human & social capital, educate & demonstrate.

3. First in Wales (organising theme) – shared access scheme, DIY (Rural Technologies Wales), Openreach (improved CFP), Stranded Assets

4. Mutual Learning (organising theme) – feedback loops/key learning (PCC to DCMS to WG – what worked/what didn't – City Deal – take up rate 20-25% but PCC 70%), educate & demonstrate. Potential failure (PCC EO scheme, suppliers and resourcing, labour shortage).

5. Hubs (organising theme) – critical success factor? INCA, Local Authority (new hub), People (value of mediators & knowledge brokers).

PART 3 – UK, WELSH GOVERNMENT and LOCAL AUTHORITY - analysis



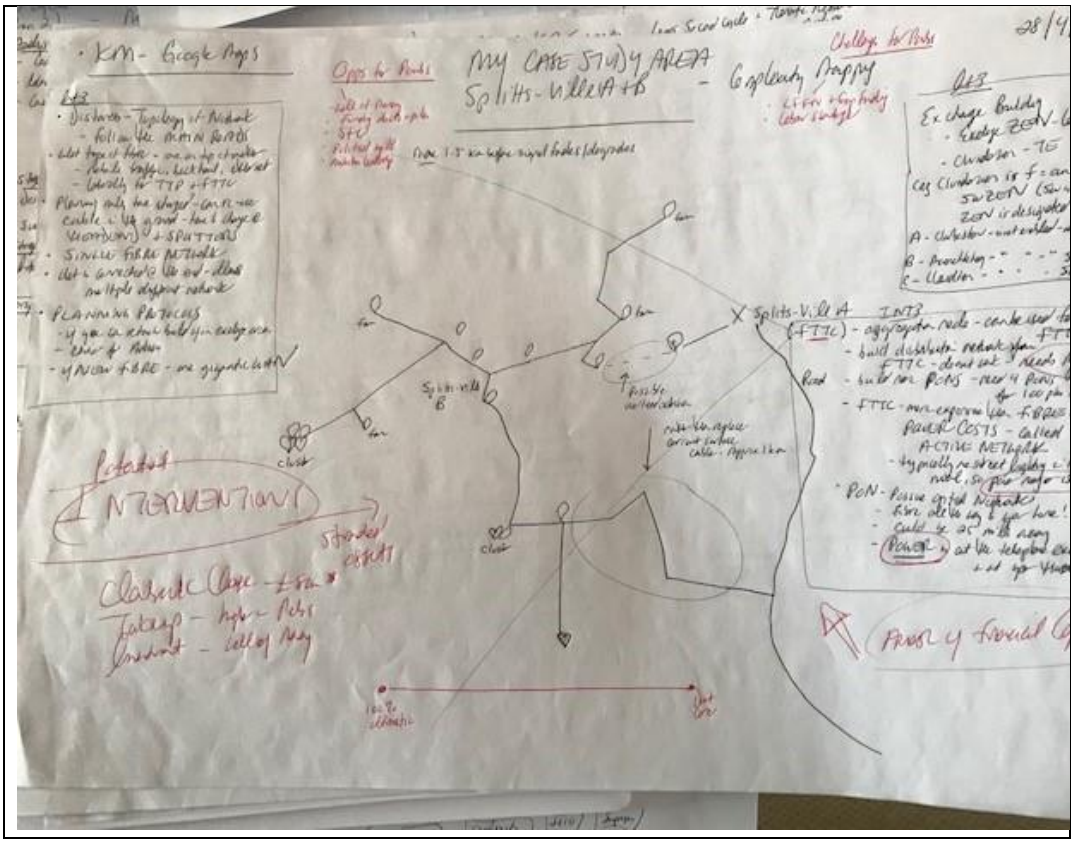
1. UK Government (DCMS) – reality on how networks are built, build inside out (COMPLEXITY code) – power, backhaul, full fibre

2. WELSH GOVERNMENT (global theme) – Taskforce (organising theme) – new because communication with local authorities not good, local insight required, final few is complicated, talk to people locally to understand complexities, light bulb moment.

3. LOCAL AUTHORITY (new key hub – global theme) – Pembrokeshire (organising theme) - proactive leadership, Wall of Money (LFFN, RGC, Vouchers, Private funding, WG New Community Fund, Swansea Bay City Deal).

4. Digital Transformation Group (organising theme from local authority) – barrier busting group, conflict resolution, mediator/knowledge broker (key theme), Joined up approach (internal steering group), SINGLE POINT OF CONTACT (HUB – central to this process).

EXAMPLE J.19 - POTENTIAL INTERVENTIONS – Case Study Area



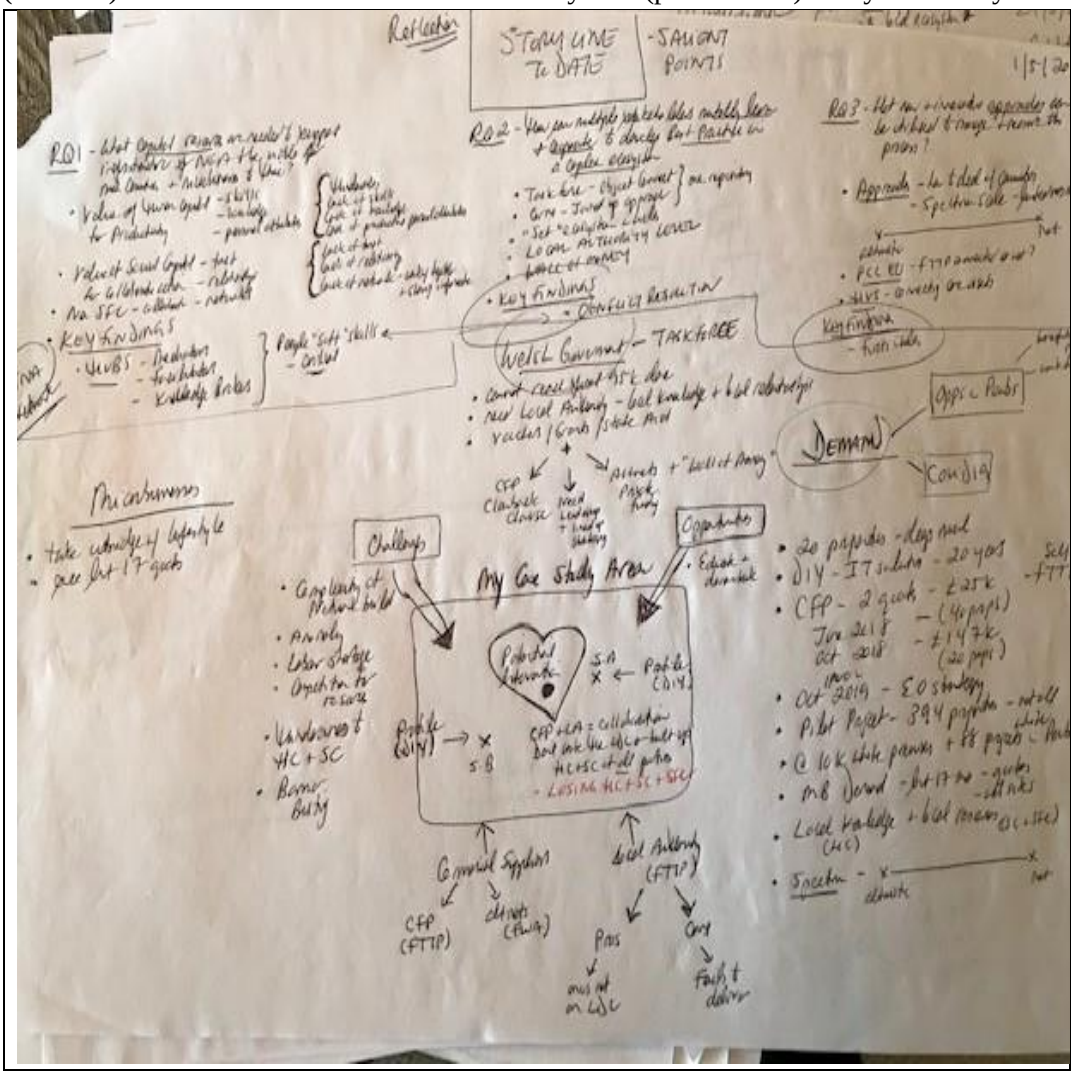
1. Mapping Case Study Area – to identify potential intervention areas based on supply & demand analysis.

2. Identification of SUPPLY ECOSYSTEM (NETWORK BASED) & DEMAND ECOSYSTEM (PLACE-BASED).

3. ***DEMAND CODING AND ORGANISATION – was through VIGNETTES****. Most of the demand data is responses to RSCAT and the LDCs experience as IT experts living in a deep rural Welsh hamlet. The DATA DISPLAY was rich and thick description of LDC and MBs experiences in deep rural Pembrokeshire.*

EXAMPLE J.20 - ZOOM OUT - STORYLINE TO DATE – REFLECTION

Created an overall reflection map on the salient points under RQ headings and Key Findings under each RQ. Focusing on SALIENT POINTS/CSFs and how the Supply Ecosystem (network) related to/influence the Demand Ecosystem (place-based) in my case study area.



1. RQ1 – what capital resources are required?

- *Value of human capital for productivity – skills, knowledge, personal attributes & hinderances therein*
- *Value of social capital for collective action – trust, relationships, networks & hinderances therein*
- *New shared financial capital – collaboration opportunities*
- *KEY FINDINGS – HUBS – mediators, facilitators, knowledge brokers, People/Soft skills – critical*

2. RQ2 – how can multiple stakeholders mutually learn?

- *Taskforce – Object Connect – one repository*
- *Carmarthen – joined up approach – one repository*
- *Set ecosystem in Wales*
- *Local Authority Level*
- *Wall of Money*
- *KEY FINDINGS – conflict resolution*

3. RQ3 – new innovative approaches

- *How to deal with communities*
- *Spectrum scale – limited resources*
- *PCC EO – FTTP connected or not?*
- *HVS – connecting core assets*
- *KEY FINDING – First in Wales*

4. WELSH GOVERNMENT – TASKFORCE

- *Cannot reach final 95k alone*
- *Need Local authority – local knowledge, local relationships*
- *Vouchers, grants, state aid + CFP clawback clause, Altnets Wall of Money, private funding*

5. DEMAND – opportunities in Pembrokeshire - benefits of rural, work from home – COVID19

6. MY CASE STUDY AREA

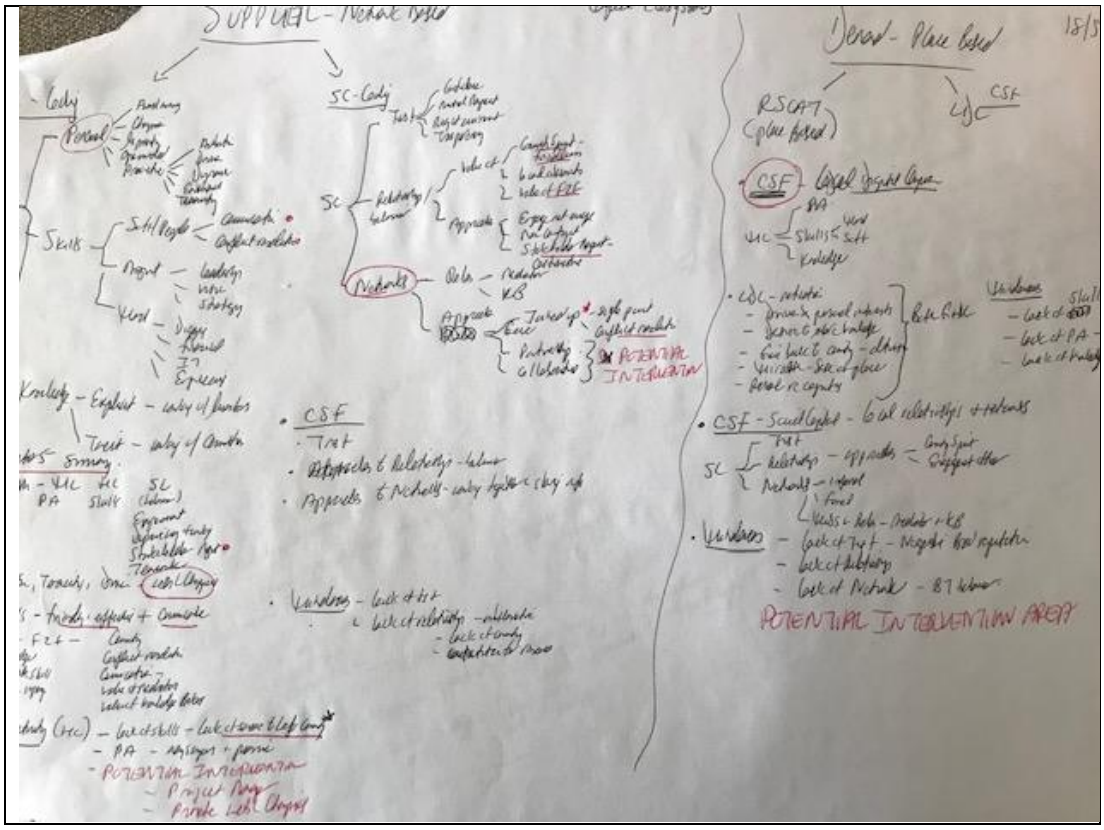
- *Challenges – complexity of network build, OR anomaly, labour shortage, competition for resources, hinderances to HC & SC, barrier busting*
- *Opportunities – educate & demonstrate*
- *POTENTIAL INTERVENTION – CFP and LA = collaboration – don't waste the LDC or built-up HC, SC, SFC for all parties*

7. MICROBUSINESSES – take offense with lifestyle business labelling – see INT17 quotes

STAGE 3 - DATA DISPLAY **Case study report structure (observation, interview, document findings)** **(Chapter 5 – nation-level) and detailed TNA analysis (Chapter 6) to answer RQs**			
STEPS	**METHOD**	**PROCESS**	**EXAMPLE**
10	Guide to Case study report (Section 4.7.4)	How to present findings – created coding maps	Example J.21 – ZOOM OUT – coding maps
		Chapters 5 & 6 – review most salient/KQ maps & codes/mind maps - CSFs	Example J.22 – How to display quotes
		How to write up Chapters 5 & 6 – map out case study & TNA structure	Example J.23 – Writing it up
		Supplier Ecosystem – summary – structure headings	Example J.24 – supplier ecosystem - summary
11	Illustrative example – to capture complex ecosystems	Complex supply ecosystem – created map using Mr. P as illustration for SV-A example - findings for network-based ecosystem – reaching the final few	Example J.25 – complex ecosystem – network based

		Complex demand ecosystem – created map using Mr. G - as illustration for SV-A example - findings for place-based ecosystem – reaching the final few	Example J.26 – complex ecosystem – place based
		Synthesis map to integrate results – how to best to present findings	Example J.27 – Synthesis Maps
12	Demand display	Rich and thick description of demand ecosystem using VIGNETTES & quotation maps of LDC & MBs experiences	Chapter 5 (Section 5.8)
13	Summary of findings	The CONTEXTUAL FINDINGS – mapped to Case Study Report outline to answer RQs – CHAPTER 5	Example J.28 – data display – chapter 5
		The THEMATIC NETWORK ANALYSIS FINDINGS – mapped to answer RQs – CHAPTER 6	Example J.29 – data display – chapter 6

EXAMPLE J.21 – ZOOM OUT – Supply & Demand Ecosystems – coding maps

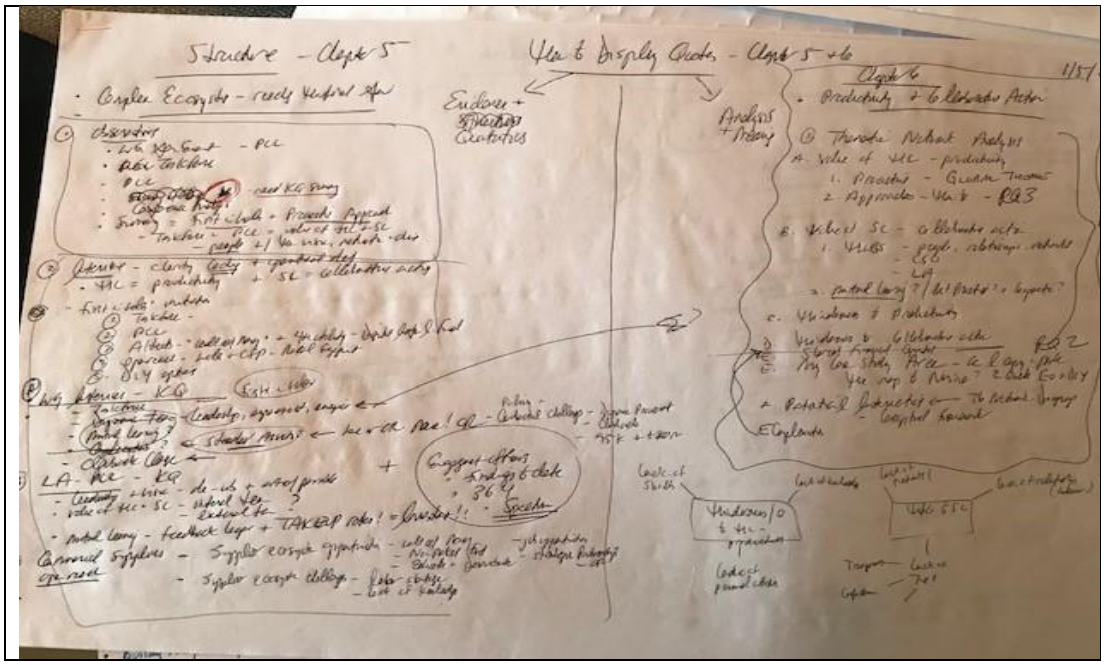


1. Coding maps – to provide structure & pictures

2. Supply – network based

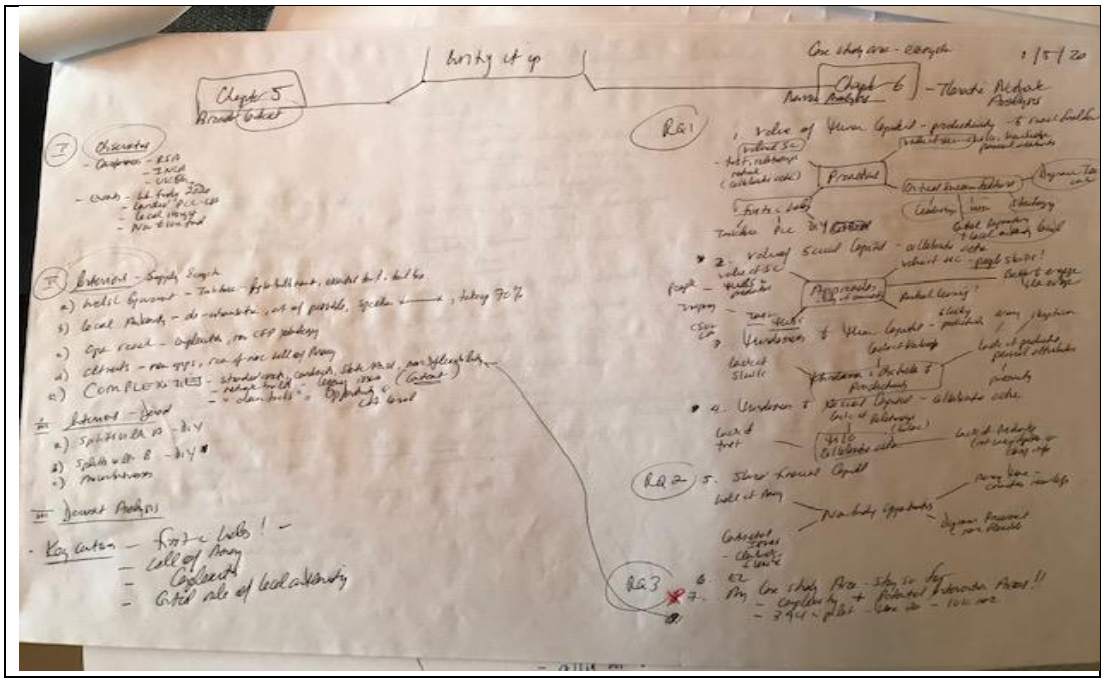
3. Demand – place based

EXAMPLE J.22 - How to Display Quotes – Chapters 5 & 6



1. Structure – Chapter 5 – complex ecosystems – evidence & quotations
2. Observations, Interview's supply and demand – evidence & KQs
3. Chapter 6 – productivity and collective action – evidence & meaning - CSFs
4. Thematic network analysis – RQ1, 2 & 3

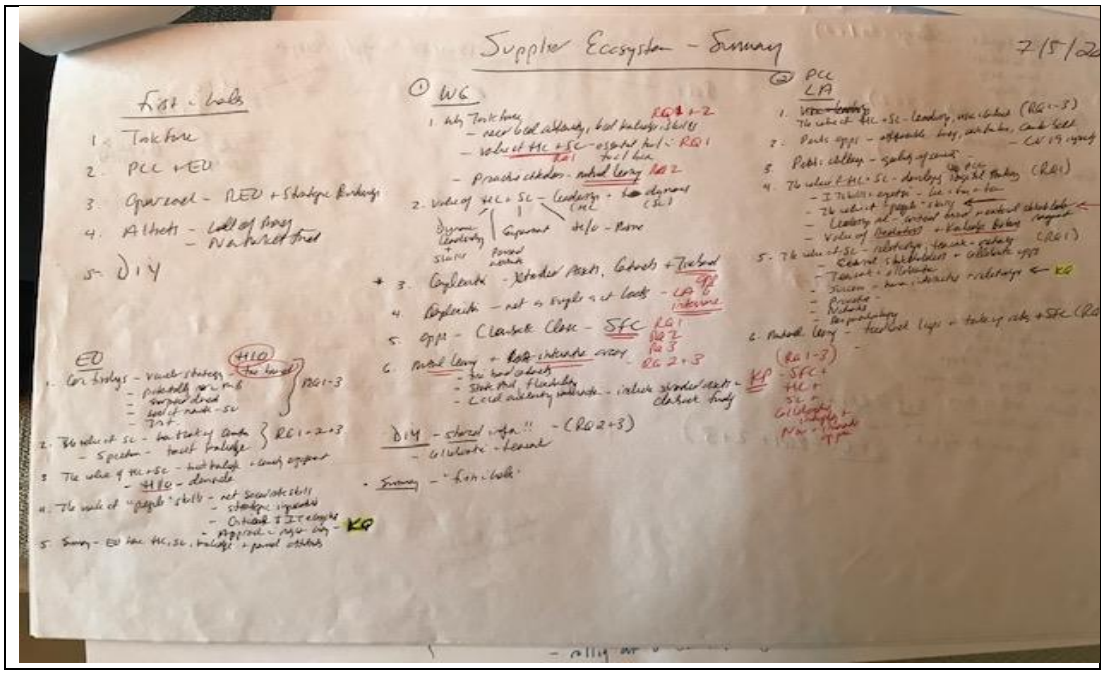
EXAMPLE J.23 - Writing it Up – Chapter 5 & 6



1. Chapter 5 – broader context – using guide to case study report

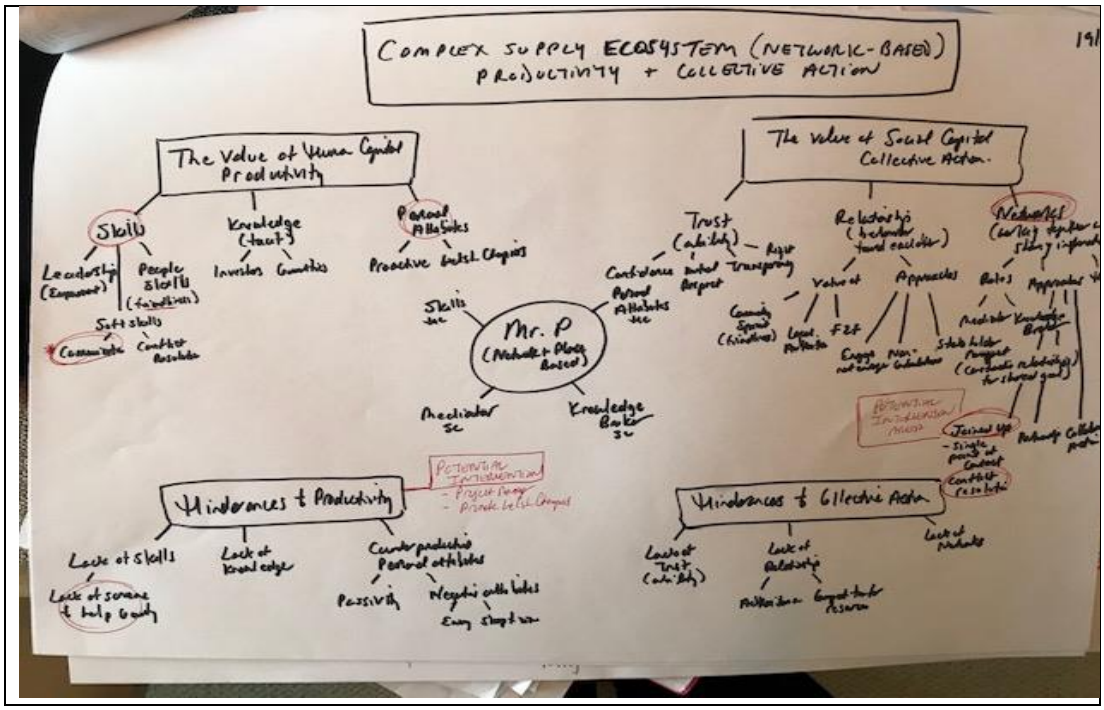
2. Chapter 6 – narrow analysis – using TNA analysis to answer RQs

EXAMPLE J.24 - Supplier Ecosystem – summary



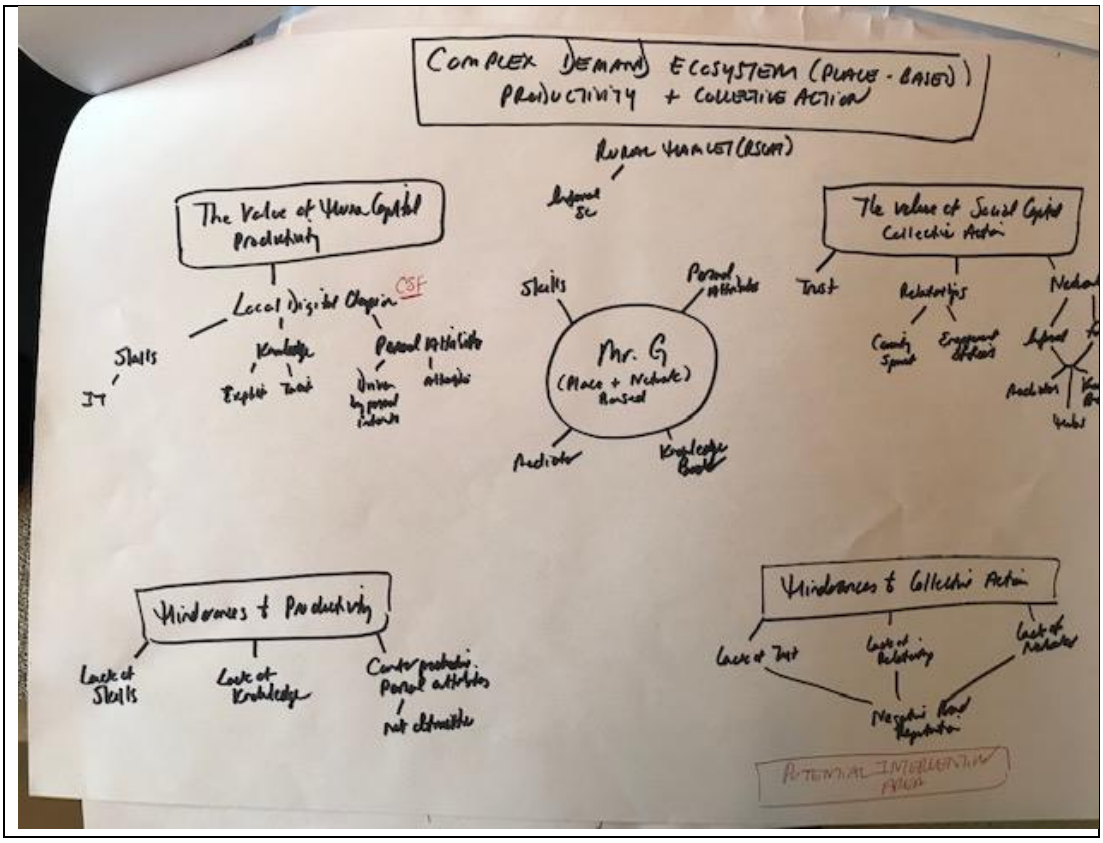
1. Chapter 5 - mapping out Supply Ecosystem findings - First in Wales, Welsh Government, PCC/Local Authority, Engagement Officers

EXAMPLE J.25 - Complex Ecosystem – network based



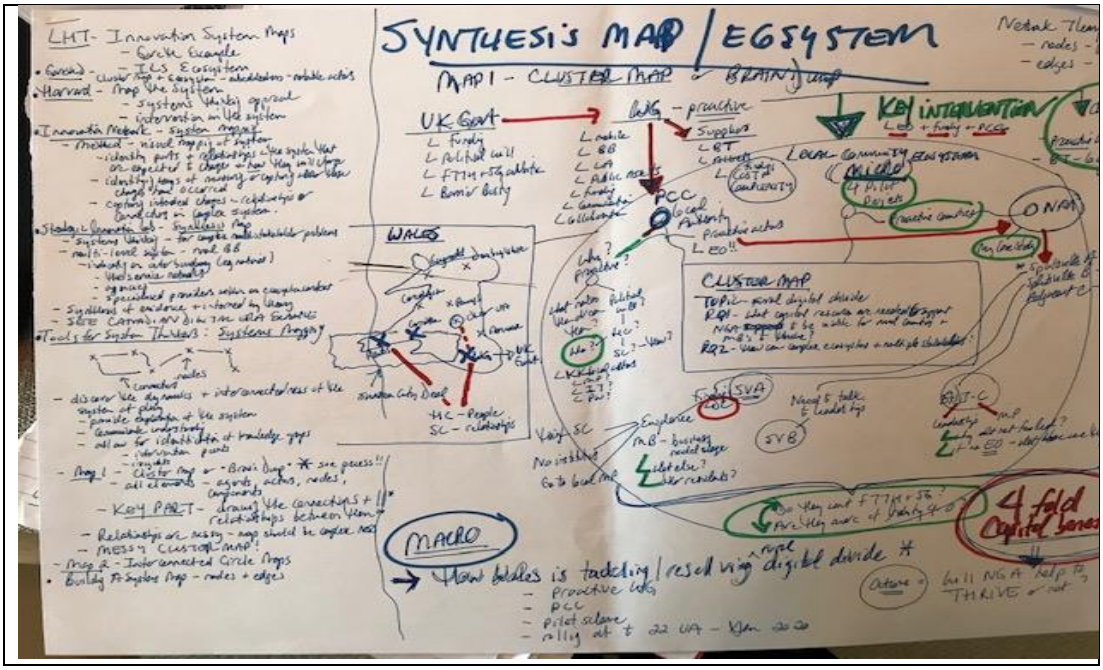
1. Mapping out Complex Ecosystem Networks – illustrated with Mr. P example SV-A – reaching a final few & hard to reach rural hamlet in Pembrokeshire

EXAMPLE J.26 - Complex Ecosystem – place based



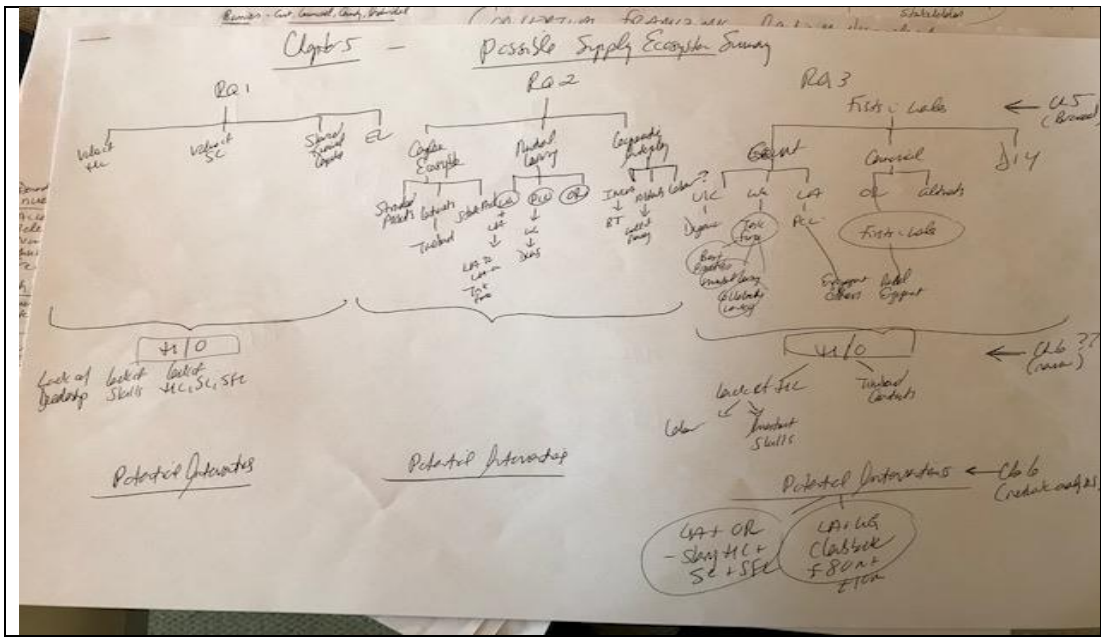
1. Mapped out Complex Ecosystem Networks – illustrated by Mr. G example for SV-A – reaching a final few & hard to reach rural hamlet in Pembrokeshire

EXAMPLE J.27 - Synthesis Map – ecosystem



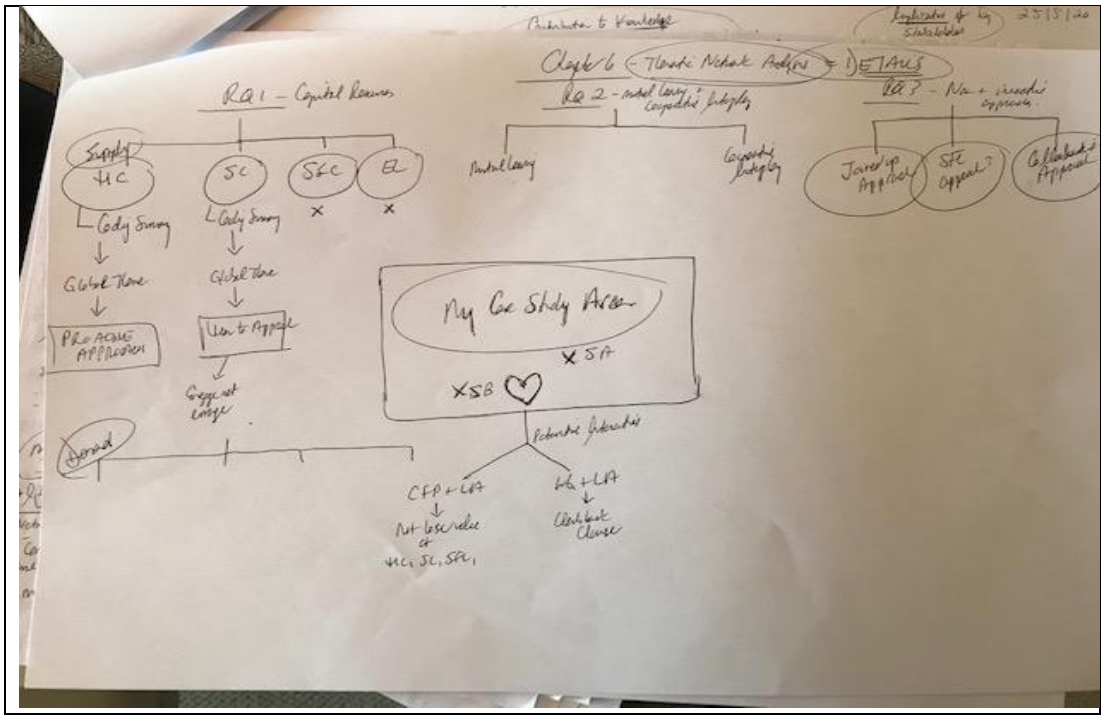
1. Cluster Map – brain dump – to capture all relevant items – macro/micro/key interventions

EXAMPLE J.28 - CHAPTER 5 – DATA DISPLAY ORGANISATION



1. Chapter 5 - follow case study report outline to answer RQS - potential interventions

EXAMPLE J.29 - CHAPTER 6 – DATE DISPLAY ORGANISATION – TNA



1. Chapter 6 - Thematic Network Analysis – details – mapped to RQs and case study area

Appendix K – Data analysis – Codebook & Time schedule

The codebook was constructed from deductive (*a priori*) & inductive (participant answers to RQs & emergent themes).

Table K.1 Data analysis - code book – operational definitions – human capital

***A PRIORI* CODE BOOK AND DATA CODING -HUMAN CAPITAL - April 2020**

HUMAN CAPITAL – a unique set of *skills, attributes and knowledge* of an individual that contributes to PRODUCTIVITY (Schultz, 1961). SKILLS, KNOWLEDGE, PERSONAL ATTRIBUTES.

- **SKILLS –** NOUN (business) - a particular **ability** that you develop through training and experience and that is useful in a job: an ability to do an activity well, especially because you have practiced it:
- **KNOWLEDGE -** NOUN - skill in, **understanding of, or information about** something, which a person gets by experience or study: EXPLICIT AND IMPLICIT (TACIT)
- **ATTRIBUTE:** a **quality** or characteristic that someone or something has:
- NOUN – a word that refers to a person, place, thing, event, substance, or quality:
- VERB (noun) - a word or phrase that describes an action, condition, or experience:
- ADJECTIVE - a word that describes a noun or pronoun:
- ADVERB - a word that describes or gives more information about a verb, adjective, adverb, or phrase:

	Term	Definition (ref Cambridge online dictionary)
1	**SKILL**	NOUN (business) - a **particular ability** that you develop through training and experience and that is useful in a job: **an ability to do an activity** well, especially because you have practiced it.
2	Ability	NOUN (business) - the power or skill needed to do something, or the fact that someone is able to do something:
3	Award winning	ADJECTIVE - an award-winning company or product has won an award in a competition because it has been very successful:
4	Communication	NOUN (business) - the process of **sharing information**, especially when **this increase understanding between people or groups**:
5	Competence	NOUN - the ability to do something well: an important skill that is needed to do a job:
6	Foresight	NOUN - the ability to judge correctly what is going to happen in the future and plan your actions based on this knowledge:
7	Leadership	NOUN - the set of characteristics that make a good leader: the position or fact of being the leader: Leadership is also the people who are in charge of a government or group:

8	Multi-skilled	ADJECTIVE - able to do a lot of different things:
9	People skills	NOUN - the ability to deal with people in a **friendly** and effective way that achieves good results:
10	Planning	NOUN (business) - the process of planning activities or events in an organized way so that they are successful or happen on time:
11	Problem solving	NOUN - the process of finding solutions to problems: e.g., problem-solving **abilities/skills/strategies.** The program offers training in basic problem-solving strategies and is suitable for all levels.
12	Soft skill	NOUN – people's ability to **communicate** with each other and work well together.
13	Strategy	NOUN – (business) the way in which a business, government, or other organization carefully plans its actions over a period of time to improve its position and achieve what it wants: a way of doing something or dealing with something:
14	Successful	NOUN and ADJECTIVE (business) - achieving the results that were wanted and hoped for:
15	Vision	NOUN: an idea or mental image of something: the ability to imagine how a country, society, industry, etc. could develop in the future and to plan for this:
16	**KNOWLEDGE**	NOUN - skill in, **understanding of, or information about** something, which a person gets by experience or study:
17	Conflict resolution	*Not easily defined – a set of skills/knowledge required to resolve conflicts
18	Explicit Knowledge (hard skill)	NOUN (business) - knowledge that can be expressed in words, numbers, and symbols and stored in books, computers, etc.:
19	Understanding	ADJECTIVE - characterized by understanding; prompted by, based on, or **demonstrating comprehension,** intelligence, discernment, empathy, or the like: NOUN - mental process of a person who comprehends; comprehension; personal interpretation: intellectual faculties; intelligence; mind: superior power of discernment; enlightened intelligence: knowledge of or familiarity with a particular thing; skill in dealing with or handling something: a state of cooperative or mutually tolerant relations between people:
20	Implicit or Tacit knowledge – LOCAL knowledge (Soft skills)	NOUN - knowledge that you do not get from being taught, or from books, etc. but get from personal experience, for example when working in a particular organization:

21	**PERSONAL ATTRIBUTES**	NOUN (business) and VERB: a ***quality*** **or characteristic** that someone or something has: We know an attribute is a quality or characteristic of a person, place, or thing.
22	Altruistic	ADJECTIVE - showing a wish to help or bring advantages to others, even if it results in disadvantage for yourself:
23	Ambition	NOUN - a strong wish to achieve a particular thing:
24	Assertive	ADJECTIVE (business) - behaving confidently and not being frightened to say what you want or believe:
25	Champion	NOUN and VERB: a person who enthusiastically supports, defends, or fights for a person, belief, right, or principle:
26	Driven	ADJECTIVE (business) - if someone is driven, all their effort is directed towards achieving a particular result:
27	Enthusiasm	NOUN - a feeling of energetic interest in a particular subject or activity and a desire to be involved in it, or a subject that produces such a feeling:
28	Generous	ADJECTIVE - willing to give money, help, kindness, etc., especially more than is usual or expected:
29	Generosity	NOUN - the quality or condition of being generous:
30	Inclusivity	NOUN - the quality of trying to include many different types of people and treat them all fairly and equally:
31	Inspiration	NOUN - someone or something that gives you ideas for doing something: An inspiration is also a sudden good idea:
32	Motivation	NOUN - enthusiasm for doing something:
33	PROACTIVE	ADJECTIVE - *taking action* by causing change and not only reacting to change when it happens: intending or intended to produce a good result or avoid a problem, rather than waiting until there is a problem:
34	Responsibility	NOUN - something that it is your job or duty to deal with:
35	Tenacity	ADJECTIVE -unwilling to accept defeat or stop doing or having something: holding tightly onto something, or keeping an opinion in a determined way:
36	Transparency	NOUN (business) - a situation in which business and financial activities are done in an open way without secrets, so that people can trust that they are fair and honest:
37	**BARRIER**	NOUN - something that *prevents* something else from happening or makes it more difficult: something that keeps people or things apart:
38	**HINDRANCES**	NOUN - something that makes it *more difficult for you to do* something or for something to develop:
39	**OBSTACLE**	NOUN - something that blocks you so that movement, going forward, *or action is prevented or made more difficult*

40	Envy	NOUN and VERB - to wish that you had something that another person has:
41	Skepticism	NOUN - doubt that something is true or useful:
42	Passive	ADJECTIVE (behavior) - not acting to influence or change a situation; allowing other people to be in control:
43	Passivity	NOUN - the quality or state of being passive

TOTAL = 43

Table K.2 Data analysis - code book – operational definitions – social capital

***A PRIORI* CODE BOOK AND DATA CODING - SOCIAL CAPITAL - April 2020**

SOCIAL CAPITAL – the trust, beliefs, norms, rules, and networks that constitute the value of relationships for COLLECTIVE ACTION (McElroy et al., 2016).

	Term	**Definition (Ref Cambridge dictionary)**
1	**TRUST**	NOUN (business) - belief that you can depend on someone or something: (Section 3.6.4) – trust them to do something – ability to act.
2	Confidence	NOUN (business) – OTHERS - a feeling that you can trust someone or something to work well or behave as you expect: YOURSELF - the quality of being certain of your own ability to do things well:
3	Mutual respect	MUTUAL (ADJECTIVE, business) - used to describe something that is done or felt by all or both people in a group: RESPECT - NOUN and VERB - to admire an ability or good quality, or to admire someone for the ability or qualities that person has: to feel or show admiration for someone or something that you believe has good ideas or qualities: to treat something or someone with kindness and care: to accept that something is right or important and not to attempt to change it or harm it: to think that it is important to obey a law or rule:
4	Transparent	ADJECTIVE (business) - transparent business and financial activities are done in an open way without secrets, so that people can trust that they are fair and honest:
5	**RELATIONSHIP**	NOUN (business) - the way in which two or more companies, countries, or people **behave towards each other**: (SOMETHING) a **connection** between two or more facts, events, etc.:
6	Approach	NOUN – a way of doing something; an act of communicating with another person or group in order to ask for something.
7	Community Spirit	NOUN - friendliness and understanding between local people:
8	Empowerment	NOUN (business) - the process of giving a group of people more freedom or rights:
9	Engagement	NOUN (business) - an arrangement to do something, or to be somewhere:
10	Friendly	ADJECTIVE - behaving in a pleasant, kind way towards someone:

11	Confrontational (Converse if non-confrontational)	ADJECTIVE (business) - causing or involving angry disagreement:
12	Stakeholder Management	*no one definition NOUN (business) – STAKEHOLDER - an employee, investor, customer, etc. who is involved in or buys from a business and has an interest in its **success**: NOUN (business) – MANAGEMENT - the activity of controlling something, or of using or **dealing with something in a way that is effective:**
13	Teamwork	NOUN (business) - the activity of working together as a team, or the skills needed to do this:
14	**NETWORK**	NOUN (business) and VERB: a group of people or organizations in different places who **work together and share information**:
15	Competition	NOUN: a situation in which someone is trying to win something or be more successful than someone else:
16	Broker	NOUN - a person who talks to opposing sides, especially governments, making arrangements for them or bringing disagreements to an end:
17	HUB	NOUN (business) - the central or main part of something, where there is most activity:
18	Knowledge broker	Knowledge broker is the individual who facilitates the creation, sharing and use of knowledge in an organization by linking individuals with providers.
19	Mediator role	NOUN - a person who tries to end a disagreement by helping the two sides to talk about and agree on a solution:
20	Partnership	NOUN (business) an agreement between organizations, people, etc. to work together:
21	**HINDRANCES/OBSTACLES**	
22	Authoritarian	NOUN and ADJECTIVE - demanding that people obey completely and **refusing to allow them freedom to act** as they wish:
23	Bureaucracy	NOUN (business) – WORKPLACE - complicated rules, processes, and written work that **make it hard to get something done**: MANAGEMENT - a system for controlling or managing a country, company, or organization that is operated by officials who are employed to follow rules carefully:
24	**NORMS**	NOUN (business) - an accepted standard, or a way of behaving or doing things that most people agree with:
25	**BELIEFS**	NOUN - the feeling of being certain that something exists or is true: something that you believe:
26	**RULES**	NOUN (business) - an accepted principle or instruction that states the way things are or should be done, and tells you what you are allowed or are not allowed to do: VERB - To decide officially:

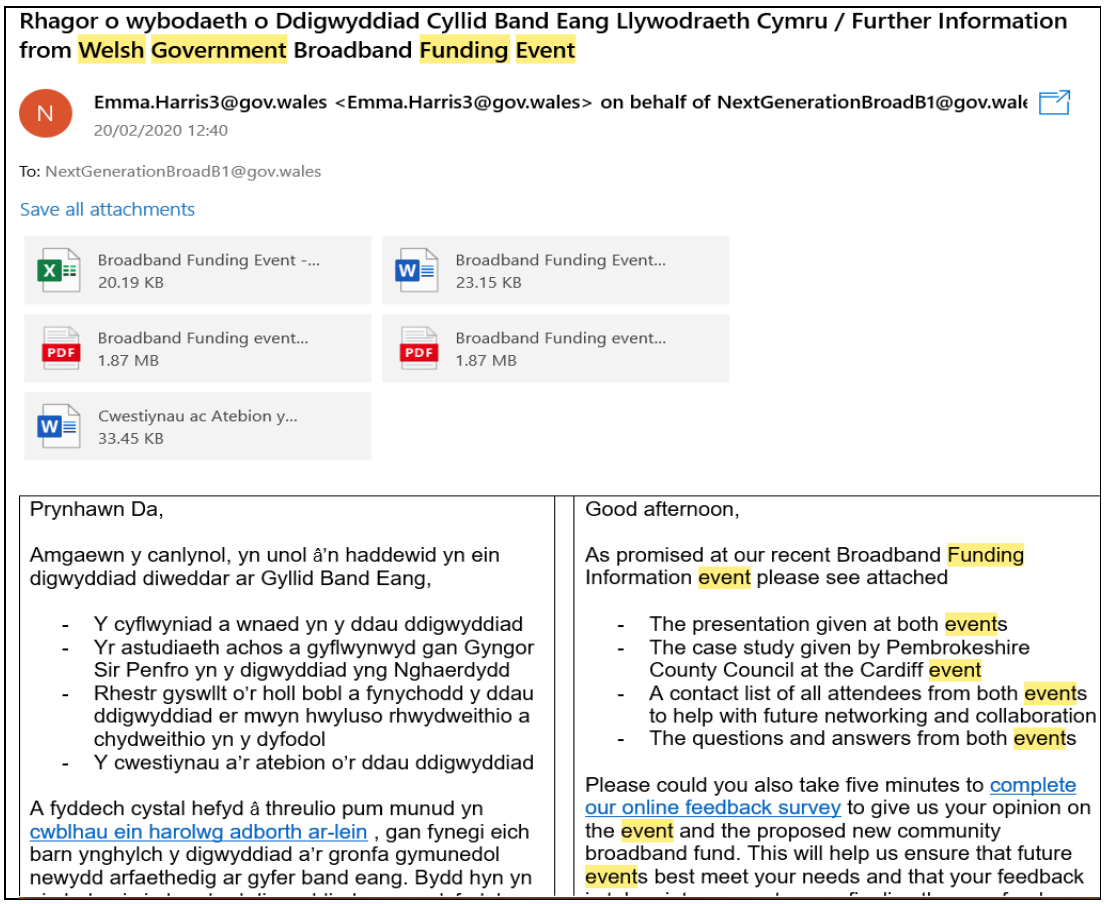
TOTAL = 26

Table K.3 Data analysis – general time schedule

Data	Analysis Phase	Timeframe
Observation data analysis	Phase 1 & 2	Sept 2019 - March 2020
Document analysis	Phase 1 & 2	Sept 2019 - March 2020
Interviews & transcription	Phase 1 & 2	January – March 2020
Interview transcription analysis – first cycle	Phase 1 & 2	April 2020
Operational definitions – clarify	Phase 3 & 4	April 2020
Coding analysis – second and third cycle	Phase 3 & 4	April 2020
Coding for themes	Phase 3 & 4	April 2020
Defining and naming themes	Phase 5	May 2020
Producing the report	Phase 6	June 2020

Appendix L – Data Analysis – Documents (Tier Three)

Figure L.1. Welsh Government Broadband Funding Event (January 22, 2020) – presentation slides.



Rhagor o wybodaeth o Ddigwyddiad Cyllid Band Eang Llywodraeth Cymru / Further Information from Welsh Government Broadband Funding Event

N

Emma.Harris3@gov.wales <Emma.Harris3@gov.wales> on behalf of NextGenerationBroadB1@gov.wale

20/02/2020 12:40

To: NextGenerationBroadB1@gov.wales

Save all attachments

Broadband Funding Event -... 20.19 KB

Broadband Funding Event... 23.15 KB

Broadband Funding event... 1.87 MB

Broadband Funding event... 1.87 MB

Cwestiynau ac Atebion y... 33.45 KB

Prynhawn Da,

Amgaewn y canlynol, yn unol â'n haddewid yn ein digwyddiad diweddar ar Gyllid Band Eang,

- Y cyflwyniad a wnaed yn y ddau ddigwyddiad
- Yr astudiaeth achos a gyflwynwyd gan Gyngor Sir Penfro yn y digwyddiad yng Nghaerdydd
- Rhestr gyswllt o'r holl bobl a fynychodd y ddau ddigwyddiad er mwyn hwyluso rhwydweithio a chydweithio yn y dyfodol
- Y cwestiynau a'r atebion o'r ddau ddigwyddiad

A fyddech cystal hefyd â threulio pum munud yn cwblhau ein harolwg adborth ar-lein , gan fynegi eich barn ynghylch y digwyddiad a'r gronfa gymunedol newydd arfaethedig ar gyfer band eang. Bydd hyn yn

Good afternoon,

As promised at our recent Broadband Funding Information event please see attached

- The presentation given at both events
- The case study given by Pembrokeshire County Council at the Cardiff event
- A contact list of all attendees from both events to help with future networking and collaboration
- The questions and answers from both events

Please could you also take five minutes to complete our online feedback survey to give us your opinion on the event and the proposed new community broadband fund. This will help us ensure that future events best meet your needs and that your feedback

Figure L.2 Picture of PCC Digital flyer and poster at bus stop

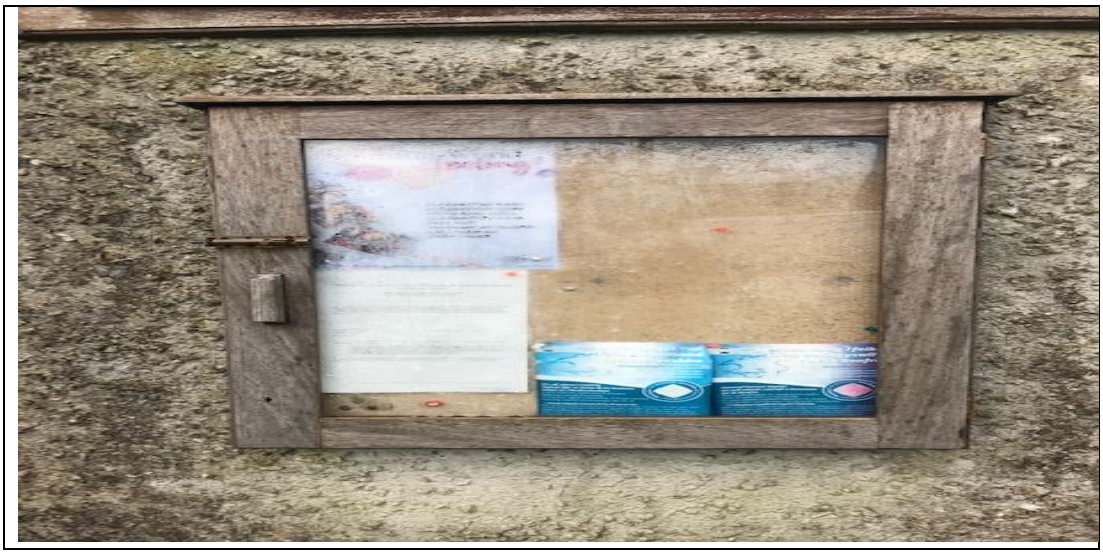


Figure L.3 Sample of PCC County 2019 survey infographic (Twitter)

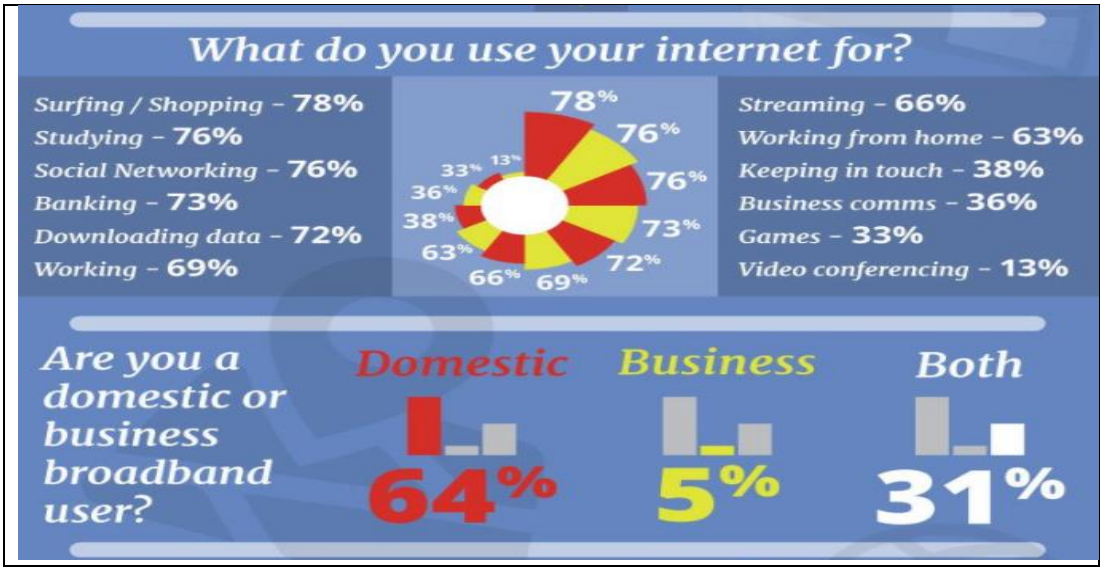


Table L.4 Summary of instructional videos to explain the complexities of full-fibre network build

	Supplier	***Focus***	***Author***	***Reference***
1	Commercial	UK - FTTH overall technical architecture explanation.	The Optical Networker	(The Optical Networker, 2017, September 9)
2	Altnet	USA - FiberPlanIT – software explaining complicated overlaid network design, costs & decision making.	Realworld2all	(Real World Systems, 2015, July 15)
3		Denmark - FTTH deployment – details of cabling, ducting, micro-trenching.	GM Plast A/S	(GM Plast A/S, 2013, October 3, 2015, September 8)
4		Denmark - FTTH in rural – digging trenches across long distances & challenge when reaching the village.	GM Plast A/S	(GM Plast A/S, 2015, March 24)
5	DIY	UK - FTTH "Do it Yourself" (DIY) end to end instruction – including details of equipment used.	John Watkins	(Watkins, 2016, October 16)
6	Openreach	UK - Ghost Plan – detailed plan to build full fibre networks.	Openreach "First Ambition"	(Openreach, 2018)
6		UK - Cabling Surveys – detailing the complications of underground duct construction for one urban street.	BT Film Archives – 1960s	(BT Film Archive, 1960)
7		UK - Openreach Fibre Broadband – explaining the evolution of changing over from copper to full fibre – FTTC, FTTH and some wireless, satellite & TV Whitespaces for the hard-to-reach areas.	Openreach	(Openreach, 2012, June 21)

**All Appendix references are included in main references listed below*

Appendix M – Community Capital Framework (CCF)

The original RSCAT assessment tool was to incorporate rural community capital assessments. As explained in section 4.10.4 and divergence change model (2) the original assessment will now form part of future recommendations (Chapter Eight).

Table M.1 Combined summary definitions or rural *assets* - to clarify variables for capital inquiry.

Community Capital Framework		**Rural Broadband & IM**	**Which assessment Tool?**
Built Capital	Human-constructed infrastructure (e.g. community broadband network). It is often equated to community development, but it is effective only when it contributes to other community capitals.		**RSCAT**
Cultural capital	Determines how one sees the world, what one takes for granted, what one values, and what things one thinks are possible to change. Cultural hegemony allows one social group to impose its symbols and reward	Benefits derived from cultural goods, activities, and participation, which can boost the prestige and competence of a community, having both material and symbolic value for those who can access them – can be tangible (architecture, artefacts) or intangible (stories, traditions).	**Will not be measured, unless mentioned in interviews**
Financial capital	Includes savings, income generation, fees, loans and credit, gifts, philanthropy, taxes and tax exemptions. Community financial capital can be assessed by changes in poverty or the increased assets of local people.	Shared financial capital – variety of resources rather than one financial source – from government, local authorities, agencies, charitable, crowd funding, income, and own investment. Blending of municipal, private, and non-profit organizations that provide resources for community ICT development.	**HVS interviews & RSCAT**

Natural/ Environmental capital	Air, water, soil, biodiversity and weather that surrounds and provides both possibilities and limits to community possibility. NC influences and is influenced by human activities	SFBB benefits definition – less travel reduces carbon emissions, benefits of using Skype and other video applications. Social media reduces the need to travel. Negative EC – increased capacity impacts transportation, pollution, and infrastructure needs – expansion of physical space. Address sustainability debates re climate change.	**HVS interviews & RSCAT**
Political capital	Ability of a community or group to turn its norms and values into standards, which are then translated into rules and regulations that determine the distribution of resources. PC is also mobilised to ensure that those rules, regulations and resource distributions are enforced.		**Will not be measured, but will be reflected in HVS & RSCAT**
Focus on human & social capital as critical success factors			
Human capital	Includes education, skills, health & self esteem	The unique set of skills, knowledge, education, learning and awareness we can apply individually or collectively for the benefits of self or others. It is a non-financial value-add.	**HVS interviews, RSCAT & NGA self-assessment**
Social capital	Involves mutual trust, reciprocity, groups, collective identify, working together, and a sense of a shared future. Bonding social capital consists of interactions within a specific group or community and bridging social capital consists of interactions among social groups.	The trust, belief, norms, rules, and networks that constitute the value of relationships for collective action. The community level (or group) rather than at the individual level of how people can be valued as an asset.	**HVS interviews, RSCAT, NGA self-assessment**

		SFBB benefits – communities could remain intact and not have to relocate to access reliable Internet. Maintain social cohesion and reduce outmigration.	

Appendix N – NGA Thrive Assessment – Future research

(Disclaimer – the original assessment for this thesis was to include a 'thrive' assessment based on the four-fold capital benefits to rural communities. However, due to unforeseen changes within the project area, time did not allow to action this assessment. Hence, it was moved to future research. Below is the work started and captured by this researcher).

N.1 Thriving in rural broadband context (previously OBJ4)

To thrive in this context is to "grow, develop and prosper" an individual's human, social, environmental and financial capital in relation to NGA (Section 1.4). The clarification of definitions for thrive and wellbeing were addressed in Chapter Two (Section 2.3.5). There are two aspects to the thrive assessment, because the aim is to provide mutual learning and mutual benefits for all stakeholders (e.g. the quintuple helix). The supply "thrive" element for market players will be take-up of the service and resolution of returns on investment (ROI). The "thrive" element will be determined by the rural communities themselves, but if the community is thriving, then the governmental parties will have "thrived" within their objectives.

Cultural and identity capital are significant assets, but more difficult to define in this research context so will not be included in the self-assessment. The four-fold capital benefits identified as a direct impact of SFBB will be used in this instance. Other capitals are considered outside the scope of this thesis but could be assessed in future research in this field.

N.2 Defining "thrive" in a rural community context (previously section 2.2.5)

The term "wellbeing" is a buzzword adopted by many governments to rate the happiness or health of its citizens and benchmark how government agencies are performing in any given area (Ganju, Pavlou, & Banker, 2016; Hutton & Baker, 2018).

For this study, operational definitions for well-being or to thrive need to be considered**.** Operational definitions are necessary for a scientific approach and to identify the concepts to be measured (Bryman & Bell, 2015). For example, what is meant by wellbeing? It cannot be assumed to refer to health because the term can be interpreted by others to mean a sense of peace. Burns (2000) states concepts, such as wellbeing, can refer to a score over a criterion level on a wellbeing scale; the scale criterion can help others understand what is meant by wellbeing in the context of the study (p. 6). For example, to set a criterion for mental health well-being, the question might be "on a scale from one to ten, how happy do you feel?" or vice versa "on a scale from one to ten, how sad do you feel?" The questions should not be open-ended, but relevant to a timeframe (e.g. this day, week, month or throughout the year) and within a specific context (e.g. happy or sad about exam results). Confirming operational definitions and developing a set of criteria relevant to the study is essential to explain what is being measured and why.

Well-being is defined as *"the state of being happy, healthy, or prosperous"* (Well-being, n.d.). Although the term well-being is used extensively throughout academic and governmental literature, it does not adequately reflect this study's output.

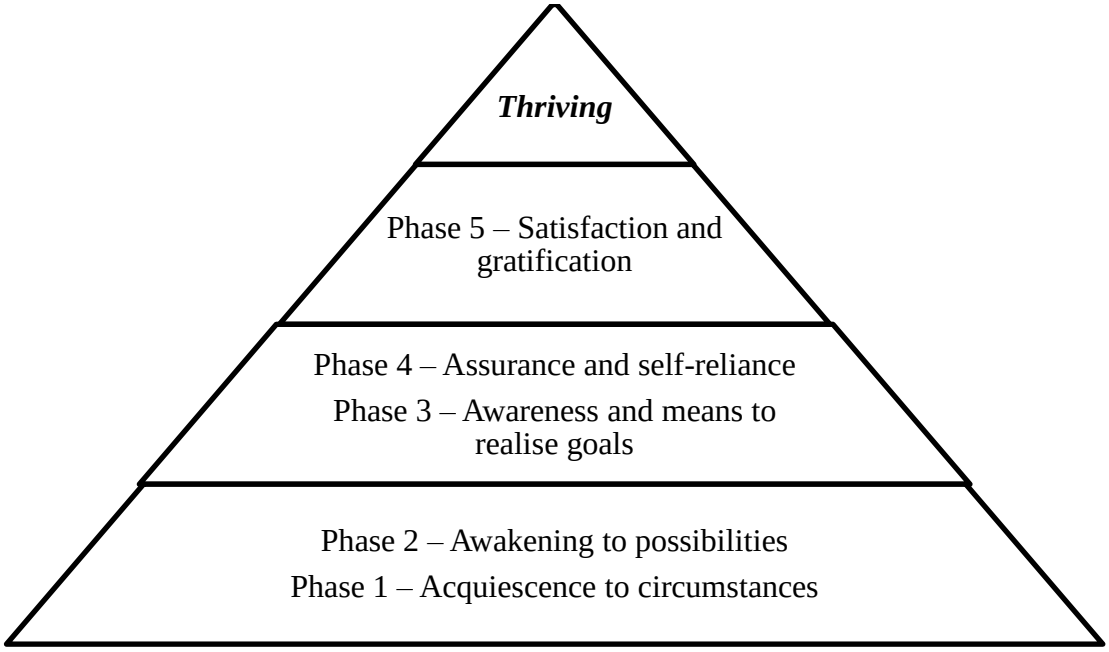
Happiness and health are not necessarily related to this topic unless the research was focused on determining if mental health or telehealth services had their desired effect.

The term and definition to thrive and *"grow, develop and prosper"* (Thrive, n.d) is more suitable to this context and is similarly used in governmental and academic studies related to broadband and rural areas (Hutton & Baker, 2018; Kaufman, 1959; Shucksmith et al., 2012). Hence, the term to thrive will be used to measure the output of NGA services in conjunction with the four-fold benefits within a rural case study.

Cantril Self-Anchoring Scale

Psychologist Hadley Cantril (1965) devised the Self-Anchoring Striving Scale. The scale aimed to identify personal and national aspirations (or motivations) on what an individual want or yearns for (Cantril, 1965, p. 8). Glatzer & Gulyas (2014) definition is *"an instrument to measure people's attitudes towards their life and its components in various respects. The original scale contains a ladder with 11 steps, and the end points of the scale are defined by the respondents in terms of their best and their worst life experience"* (p. 509). Cantril (1965) concludes by identifying the five phases of development (Figure 3.3).

Figure N.1 Cantril's (1965) phases of development adapted bottom-up (p. 309)



Although these phases were developed as a result of the findings to address individual and national fears and aspirations, they can provide a framework of motivations of people moving from surviving to thriving with digital technology.

Gallup uses Cantril Self-Anchoring Scale

Conversely, Gallup uses the Cantril Self-Anchoring (Gallup, n.d) because of the self-referencing. Cantril developed the scale in relation to the patterns of human concerns

(1965). Gallup's mission is to continue this work through its various polls on well-being in and out of the workplace.

According to Gallup (n.d), the Self-Anchoring scale consists of the following to develop the "thriving, struggling and suffering" categories. (p. 1).

1. Imagine a ladder with steps numbering zero (bottom) to 11 (top) of the ladder.
2. The top of the ladder represents the best possible life for you (thriving) and the bottom of the ladder represents the worst part of your life (suffering).
3. On which step of the ladder would you say you personally stand at this time? (ladder in the present tense).
4. On which step do you think you will stand about five years from now (ladder in the future tense).

The Cantril scale has been used widely by Gallup, including over 150 countries through the Gallup's World Poll (Gallup, n.d). Equally, other researchers from various academic fields have modified the concepts to suit their needs (Glatzer & Gulyas, 2014). The Self-Anchoring Scale allows respondents to express how they personally feel, which makes it a better tool for objectivity and validity.

For this thesis, themes and variables have been adapted from the literature to inform the study. Thus, the Cantril Self-Anchoring Scale has been adapted as the "Self-Assessment Scale" to reflect the rural broadband "thriving element" in relation to the four-fold capital benefits of "growing, developing and prospering" one's human, social, environmental and financial capital. Notably, Cantril uses the term "suffering", but in the context of this thesis the term "surviving" is better placed to reflect ICT impacts.

Rural user adoption – laddering technique

A notable insight from Peronard & Just (2011) study on user motivation to adopt rural broadband, the authors applied the "laddering technique" to identify individual aspirations for adoption. The authors adapt Means Theory to analyse what users think about a product's attributes (e.g. advantages and disadvantages), its consequences and the personal values attached to those findings (p. 692). The ladder technique asks probing questions into the rural broadband (product) to enquire why the product is important to them, what are the consequences (e.g. time saving) and how does it relate to their personal values (e.g. faster broadband saves time shopping and more time for family). Empirical findings from the ladder technique identified five motivational patterns for rural broadband adoption (p. 695):

i. Social ties and community – improved information exchange and communications (local, global, personal and business), enhanced individual and community relationships (e.g. human & social capital).
ii. Activity, family life and innovation – better local activity, more people attending events and meetings, websites helped inform and advertise IT educational programmes (e.g. human & social capital).
iii. Stability in relation to value of innovation – faster broadband means downloading is possible to enjoy high-definition video, gaming or large data transfers (e.g. innovation becomes tangible).

iv. Perception of transparency, convenience and saving time - faster connection provides unlimited knowledge, to compare prices, saving time and money (e.g. human capital productivity and financial capital).
v. Financial consequences and the value of innovation and self-realisation – faster broadband reduces costs for citizens and business (e.g. improved supply chain negotiations) and allows freedom to explore interests (e.g. human and financial capital).

Comparable to Ashmore et al. (2015) SFBB impact study, the findings can be broken into individual and communal benefits. Unlike Ashmore et al. (2015), Peronard & Just (2011) find that both matter to rural users in the context of adoption. Ashmore et al. (2015) findings validated SFBB individual resilience as a factor (e.g. users able to take control of their futures using investment platforms and so forth), but community resilience was not fully validated as some rural residents felt excluded in the community-led context. Peronard & Just (2011) data collection was in 2009-2010 and did not specify broadband speeds. Ashmore et al. (2015) identified SFBB (30Mbps) and found faster speeds related to reliability; not speed for speeds sake. This study will continue the research by addressing gigabit-capable supply and demand inquiries.

Development of 21st century digital skills

Two final considerations in evaluating human digital capital to ensure the latest research for skills development is included. As previously stated (Section 3.6.1), the UK Government Essential Digital Skills framework includes five categories which need to be included to frame the questions: communication, handling information and content, transacting, problem solving, being safe, legal and secure online (GOV.UK, 2018, September 18).

In addition, a recent systematic literature review on 21st century digital skills (van Laar, van Deursen, van Dijk, & de Haan, 2017) found the skills required for a knowledge economy workplace include core skills such as creativity, critical thinking, collaboration, communication, information management, problem solving and technical. Contextual skills surrounding the core skills are identified as cultural and ethical awareness, flexibility, lifelong learning and self-direction (p. 532). Although these are identified as workplace skills, it is useful to identify the primary concepts as critical skills required to thrive in the new digital economy. There is an opportunity to raise awareness across the generations and assess if older users may or may not need to develop the higher-level skills.

NGA skills development

To develop the next generation of skills, the UK Government recently published the "National Standards for Essential Skills" to equip all citizens with updated digital literacy standards (GOV.UK, 2019, April 23). The "Essential Digital Skills" (GOV.UK, 2018, September 18) report summarises the skills required for life and work into five categories (p. 2).

1. Communicating – communicate, collaborate and share online.
2. Handling information and content – find, manage and store digital content safely and securely.
3. Transacting – apply for services, buy, sell, and manage transactions online.

4. Problem Solving – find solutions to problems using digital tools and online services.
5. Being safe, legal and confident online – critical cybersecurity skills and awareness.

The framework was a notable collaboration between multiple UK entities. These included Lloyds Banking Group and the Tech Partnership, overseen by a steering group including Accenture, Amazon, BT, British Retail Consortium, Corsham Institute, DfE, DCMS, DWP, Federation of Small Businesses, Good Things Foundation, Greater London Authority, Greater Manchester Combined Authority, HMRC, Microsoft, NHS Digital, Scottish Council for Voluntary Organisation and SSE (GOV.UK, 2018, September 18, p. 2). Thus, making this new framework a robust national summary to describe the skills needed for NGA adoption and exploitation.

The adaptation of Cantril's Scale to reflect Rural NGA Thrive Self-Assessment

In summary, the amalgamation of Cantril's pattern of human concerns, rural broadband adoption and the introduction of 21st century digital skills will inform the adapted "Rural NGA Thrive Self-Assessment" (OBJ4) to determine the human, social, environmental and financial capital required to thrive, or not, in a "final few" and hard to reach area (Table 3.13). Both supply and demand will need to be assessed to gauge a mutually beneficial "thrive" assessment for all stakeholders. Details of the methodology and questionnaire instruments will be explained in the following Chapter Four (methodology).

Table N.1 Adapted Cantril's Scale for NGA Thrive Self-Assessment

Category	Ladder	Demand Rating HC, SC, EC, FC	Supply Rating
Thriving	10	*Proficient and confident*	*Positive access, fast and reliable connection – are they content with their connection?*
	9		
	8		
	7		
Struggling	6		
	5	*Moderately proficient, need help*	*Moderate access but not consistent (e.g. over 2Mbps but not reliable) – do they want a more reliable connection?*
	4		
Surviving	3		
	2		
	1		
	0	*Not proficient, lack confidence, skills and knowledge*	*No access or slow connection (e.g. under 2 Mbps) – do they want a faster connection?*

**Human Capital (HC), Social Capital (SC), Environmental Capital (EC), Financial Capital (FC).*

Summary of definitions and preliminary instrument design for proficiency, developing and growing four-fold skills is summarised in the following (Table 3.14). NGA demand and take-up is critical to the success of investment, return on investment and for rural communities to benefit from "claw-back" contracts. Hence, skill development (human capital) is required to answer what capital resources are needed to support infrastructure for NGA to be viable for rural communities and microbusinesses to thrive with four-fold benefits (RQ1).

Table N.2 Summary of measurements to be adapted for instrument design

Demand-side summaries	**Five rural user motivations**	**Five essential skills**	**21st century workplace skills**	**Four-fold capital benefits**
(Section 3.5.2)	*(Peronard & Just, 2011)*	*(GOV.UK, 2018, September 18)*	*(van Laar et al., 2017)*	*(Phippen & Lacohée, 2016; SQW, 2013)*
Adoption	Use/ Relevance	Skills	Skills	Outcome
Awareness of benefits – advertising/word of mouth Expected outcomes and Self-efficacy Lack of skills, speed as reliability and cost Need versus perceived lack of need Usability and Relevance	Social ties and community Activity, family life and innovation Stability in relation to value of innovation Perception of transparency, convenience and saving time Financial consequences and the value of innovation and self-realisation	Communication - collaborate, share Handling information and content - find, manage and store digital information and content securely Transacting - register and apply for services, buy and sell goods and services, and administer and manage transactions online Problem solving - find solutions to problems using digital tools and online services Being safe, legal and secure online	*Core skills:* Critical thinking Creativity Information management Problem solving *Contextual skills:* Self-direction Lifelong learning Ethical awareness Cultural awareness Flexibility	Human capital benefits Social capital benefits Environmental capital benefits Financial capital benefits

N.3 Divergence – NGA Thrive Self-Assessment change record (3)

(Previously Section 4.10.5)

As previously explained, the intended data collection plan was based on the conceptual framework (Section 3.9) which included an NGA demand awareness intervention and thrive self-assessment. Nonetheless, due to the volume of data collection and because of the time taken to make the adjustments with the introduction of the PCC initiatives, a revised schedule and timeframe was introduced (Appendix J). Due to the time restraints, it was not feasible to incorporate the entire NGA demand self-assessment. Hence, these instruments will become part of the future research recommendations (Chapter Eight). The preliminary NGA instrument design can be found in (Appendix O).

N.4 NGA Thrive Instrument design – Cantril

The NGA Self-Assessment was a work in progress. The work was stopped as a result of the EOs in the case study area. If time had allowed, the NGA Self-Assessment would ideally have been implemented along with an Industry 4.0 demand awareness training to gauge demand feedback on whether the rural community and microbusinesses wanted to develop their skills in relation to NGA access. Hence, the following interview guide is a sketch outline example only for potential future research.

Table N.3 NGA Thrive Self-Assessment outline

Phase Four:

NGA Self-Assessment – to thrive or not

Outcome assessment - demand and supply

(Instrument 4)

December 2019

1. Introduction

The NGA self-assessment allows rural communities to express whether the NGA awareness – for both demand and supply – will have a four-fold capital benefit to thrive (e.g. grow, develop and prosper) or not.

There are five sections:

I. Section 1 – introduction to the NGA Self-Assessment Scale
II. Section 2 – NGA four-fold capital benefit - present tense assessment
III. Section 3 – NGA four-fold capital benefit - future tense assessment
IV. Section 4 and 5 – NGA supply ratings – present and future

Four-fold capital benefits - as an OUTCOME

To clarify the four-fold capital benefits related to NGA access in rural communities, the following table summarises the outcomes for individuals, microbusinesses and communities and ultimately suppliers.

Capital	Individual and collective benefit
Human capital benefit	Personal development For all stakeholders (e.g. increased productivity, access to education/self-learning). Businesses (e.g. increased productivity, access to new business and web applications).
Social capital benefit	Relationship benefits For all stakeholders (e.g. communities could remain intact and not have to relocate to access reliable Internet).
Environmental capital benefit	Sustaining the environment For all stakeholders (e.g. less travel reduced carbon emissions, benefits of using Skype and other video applications)
Financial capital benefit	Individuals (e.g. cut costs by shopping on-line for travel arrangements and manage their finances from home) Businesses (e.g. could grow their business with increased efficiencies and advertising online). All stakeholders – mutual return on investments

Section 1: NGA Self-Assessment Scale

The aim of this NGA Self-Assessment Scale is for you rate yourself - where you are now (present) and where you would like to be in five years (future).

The NGA Self-Assessment imagines a ladder and where you will place yourself on that ladder regarding *struggling, striving, or thriving.*

1. Imagine a ladder with steps numbering zero (bottom) to 11 (top) of the ladder.
2. The top of the ladder represents the best possible life for you (thriving) and the bottom of the ladder represents the worst part of your life (surviving).
3. On which step of the ladder would you say you personally stand at this time? (ladder in the present tense).
4. On which step do you think you will stand about five years from now (ladder in the future tense).

Prior to using the NGA Self-Assessment - please refer to Section 2 – to understand the surviving, struggling, and thriving criteria for the *present* tense ratings.

To understand the surviving, struggling, and thriving criteria for the future tense ratings. Please refer to Section 3.

(PLEASE NOTE – the NGA was being adapted to reflect the Essential Digital Skills before this assessment was changed as a result of the Engagement Officers, hence this section is incomplete – sketch outline only).

UK Government – Essential Digital Skills

The UK Government recently released the Essential Digital Skills guide.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/738922/Essential_digital_skills_framework.pdf

The goal of the UK Government is to upskill the nation to ensure everyone can develop these essential digital skills for life. The five areas identified are:

1. Communication – communicate, collaborate, share
2. Handling of information and context – find, manage and store digital information and content securely
3. Transacting - register and apply for services, buy and sell goods and services, and administer and manage transactions online
4. Problem solving - find solutions to problems using digital tools and online services
5. Being safe, legal and secure online - Stay safe, legal and confident online

Section 2: NGA four-fold capital benefit – *present* tense ratings

Are you prospering now with digital technologies?

Thriving – 7-10 – proficient and confident

i. Human capital – confident and proficient in using the Internet to set-up relevant accounts (e.g. Skype for video or telephone calls). Confident in the basics of cyber security (e.g. anti-virus software, automatic software updates, router protection, password management, protection against ransomware or phishing scams, VPN if required).

ii. Social capital – confident and able to use selected social media platforms to build your person al networks (e.g. NFU, Linked In, Twitter, local WhatsApp groups - or any other platform that is meaningful to your quality of life).

iii. Environmental capital – confident - more difficult to qualify, but less paper, less travel, shopping online for improved electricity or green energy vendors, connecting local community to enhance sustainability measures in your area and so forth. The ability to be proactive and contribute.

iv. Financial capital – confident to manage your own finances with banking, investment platforms, Xero accounting software (if applicable for small businesses) and so forth. Growing your "individual resilience" by taking charge of your areas meaningful to you (Ashmore 2016). Are fully aware of the opportunities to develop an on-line business or use other platforms to sell items (e.g. Amazon or eBay) or money saving items through online search.

Are you developing with digital technologies?

Struggling – 4-6 – moderately proficient, need help

i. Human capital – moderately proficient in Internet use. Can use email, Skype, WhatsApp, Linked In accounts, but only need help from more proficient users to set up accounts. Want to develop new skills but lack the confidence to learn how to find the information I need (e.g. training videos on YouTube) or MOOC (massive online course). Not aware of all the cybersecurity training on offer or how to do the basics for password protected router or managing strong passwords and so forth.

ii. Social capital – moderately proficient in using Facebook, Twitter, WhatsApp and so forth. Have not fully used the Internet to customise the groups I care about. Not sure where to start.

iii. Environmental capital – moderately proficient. Know how to shop online for better electricity or green energy deals. Use platforms like USwitch or Compare the Market.com. Use email or messaging services versus paper copies. Use online shopping and online banking, but only if I have to. Do not feel very confident in doing more than the basics.

iv. Financial capital – moderately proficient. Do some online banking, but not a lot. Do online shopping, but not fully confident in giving out my personal details. Not aware of investment platforms or how to use the money saving platforms (e.g. eBay). Not fully aware on how to start an online or offline business but could find the information if I wanted.

Are you growing with digital technologies?

Surviving – 0 – 4 – not proficient, lack confidence, skills and knowledge

i. Human capital – not proficient. Lack the confidence to use the Internet. Have basic skills like using email, but do not know how computer works or how-to set-up an email account. No cybersecurity awareness training and somewhat afraid of the risks about being online. No idea of the self-educating resources available online. Never heard of a MOOC or the variety of information available on YouTube.

ii. Social capital – not proficient. Aware of social media through the general news or through friends but have never been on a platform or engaged in connections online.

iii. Environmental capital – not proficient. May recycle or do my best to be aware of the environment, but use letters, drive to the bank, drive to do shopping, do not know of how to shop for better energy or green energy savings and so forth.

iv. Financial capital – not proficient. Have a bank account which may or may not include savings. Are not aware of any online information or investing information to grow capital. Do not know where to start. Pay a financial advisor or accountant to do it all for me. Do not understand how the Internet can save money or help me develop an income through starting an on-line business.

PRESENT tense NGA Self-Assessment

1. Imagine a ladder with steps numbering zero (bottom) to 11 (top) of the ladder.
2. The top of the ladder represents the best possible life for you (thriving) and the bottom of the ladder represents the worst part of your life (surviving).
3. On which step of the ladder would you say you personally stand at this time? (ladder in the present tense).

Category	Ladder	Demand Rating HC, SC, EC, FC	Supply Rating
Thriving	10	*Proficient and confident*	*Positive access, fast and reliable connection – content.*
	9		
	8		
	7		
Struggling	6		
	5	*Moderately proficient, need help*	*Moderate access but not consistent (e.g. over 2Mbps but not reliable) – not content.*
	4		
Surviving	3		
	2		
	1		
	0	*Not proficient, lack confidence, skills and knowledge*	*No access or slow connection (e.g. under 2 Mbps) – frustrated.*

**Human Capital (HC), Social Capital (SC), Environmental Capital (EC), Financial Capital*

Section 4: NGA supply ratings - present tense

Surviving	Struggling	Thriving
0-3	*4-6*	*7-10*
You are frustrated with your current broadband speed? Not reliable.	You are not content with your current broadband speed? Sometimes reliable.	You are content with your current broadband speed? Always reliable.

**Important note – this was the sketch outline to design the NGA Self-Assessment therefore it is incomplete but useful for future research if required.*

Appendix O – Researcher reflexivity analysis

To analyse if reflexivity has or has not had an impact on this research, the following tables (O.1 – O.3) answer the questions posed by Corlett & Mavin (2018) on how to think about, act upon and evaluate reflexive qualitative analysis.

Corlett & Mavin's (2018) situated and partial account of reflexivity theory and practice informed by *their* epistemological assumptions founded on social constructionism and poststructuralism and the reflexive practices they have engaged in (p. 21). The authors constructed and extended the questions from multiple authors (p. 24 in their Appendix) namely Alvesson et al. (2008); Cassell et al. (2005); Cousin (2010); Cunliffe (2003, 2011); Day (2012); Hardy et al. (2001); Haynes (2012); James & Vinnicombe (2002); Johnson & Duberley (2003); Orr & Bennett (2009); Pels (2000).

This researcher answers the questions posed by the authors to determine if reflexivity versus reflection has added or subtracted to the validity or trustworthiness of this research.

Please note - it is this researcher's assertion that the questions posed by the various authors are 'subjective' to their onto-epistemological world-views and contain as many biases as any mix of onto-epistemological assertions can be for any individual or even collective research analysis (as all analysis is ultimately subjective in nature). It is this researcher's assertion that the focus should be on the topic of research and the research questions and not as much on the researcher's potentially endless subjective biases and constructs.

O.1 Table - Reflexive 'thinking' questions & researcher's answers.

Questions about epistemological position & assumptions	
Reflexivity questions	**This researcher's answers**
What are my assumptions about the nature of reality & who we are as humans?	My 'assumptions' about 'reality' is that reality exists. It was here before I was born. I was born into it. I didn't create it. I appeared into the 'reality' of a world that sustains life (e.g. air, water, food). I 'assume' it was designed vs a big bang event because of this. I 'assume' reality is what I can feel, touch, smell, taste & experience. Who are we as humans? It is this researcher's assertion that we are complex & complicated, yet we share the same physiological design (e.g. skeleton, blood, skin, brain & so forth) plus emotions (which are subjective to the individual and can vary but are the same emotions across humankind – love, hate, kindness, anger & so forth). Personalities can be individual yet there are similarities in traits (e.g. propensities for people & relational skills versus mathematical skills or thinking). Hence, my 'assumptions' about the nature of reality & who we are as humans are both objective reality and subjective individuality.

What do I see as the nature of knowledge?	I 'look' at the world. I 'see' the subjective 'patch' of the world that is around me. I 'know what I know' because I have either lived, experienced or learned of it. I am physically living in South Wales. I used to live in Canada and have lived in Spain, France, New York & London. My subjective individual knowledge of the world is as I 'see' it and have experienced it thus far. In what I have learned from observing family members, friends, different societal & cultural interactions or reading various books throughout my school years & working life. My 'knowledge' base is subjective to myself but objective to certain topics which I have studied and/or experienced.
Questions about representation & truth	
In my representation of the social world, what are my underlying assumptions about the production of knowledge – how do I know & who can claim to know? Who can make claims to 'know' & represent others using qualitative approaches?	My underlying assumptions are explained above. Everyone can make claims to 'know' because we are all human beings & have a certain commonality of lived experiences. My research is about rural broadband & how to bridge the digital divide. It is more of a practical question versus any esoterically or culturally sensitive or anthropological study that may benefit more from this type of 'reflexive' analysis. I am a pragmatist when it comes to research, so a practical outcome is my declared representation in this particular research study. For example, if I was an anthropologist studying chicha libations in Peru, then this question may be relevant, but even then, an outsider 'objective' yet 'subjective' analysis can still add knowledge to this or any field of study.
How has the research question defined & limited what can be 'found'? What findings/insights do I hope to generate from this question? On what basis will these findings/insights contribute to 'knowledge' (e.g. what kinds of knowledges and I producing? How will the resultant knowledges function to shape the world (e.g. what 'truth claims' will I make?	My research question was defined after analysis of the problem area (e.g. return on investment was not commercially/financially viable to reach final few rural areas). How I defined 'capital' for this thesis will 'limit' what can be found but I declare this and why (e.g. cultural & political capital were out of scope for this inquiry). I can only focus on specific areas & build upon what others have done. I hope to find what capitals can help resolve the digital divide in Wales. <u>On what basis will these findings/insights contribute to 'knowledge'?</u> Prior to the investigation I didn't know yet, but my questions aim to draw out these answers. So, as with all research, my research questions are the key to this, but I defined it in my literature review. <u>What kind of knowledge am I producing</u>? Subjective knowledge relevant to the stakeholders involved in resolving this issue – it's a PARTIAL view of these identified experts in the field = limited knowledge but expert knowledge.

	How will this 'shape the world'? This is quite an extravagant statement – this study is not about resolving world hunger – it's an analysis to try & find solutions to a persisting problem area. What 'truth claims' will I make? My subjective/objective pragmatic findings will add to existing knowledge in the field – which I thought was the point of doing a PhD. 'Truth claims' seems very dramatic in this sense versus pragmatic contributions to knowledge. My credibility, validity, trustworthiness (Section 6.10) should address this. The 'truth claim' – is a subjective/objective analysis to contribute to answering the research questions.
What are the different ways in which a phenomenon can be understood and how do they produce different knowledge (s)?	Quantitatively, qualitatively or mixed methods. Quantitative – I would need to define variables (e.g. if I would have interviewed & identified demand characteristics, I could have tested for it and produced different knowledge). Quantitative is a different process, so this would have produced different knowledge.
How could the research question be investigated differently (e.g. from a different epistemological perspective?) What different insights may be made by taking a different epistemological perspective?	The RQ would have been investigated through a survey (possibly?). Although I needed to ask qualitative questions to stakeholders. What capitals? Could have surveyed 7 capitals instead of four-fold capitals. Could have designed a questionnaire around these. What different insights? If I did a quantitative questionnaire, then I could have learned about cultural & political capital – it would give different results, but I chose four-fold capitals as explained in introduction. My original plan was mixed method study and to ask about supply & demand. Demand training intervention & investigate where residents were at in relation to NGA. My study could have answered more demand questions. Different study = different knowledge outcomes…

O.2 Table - Reflexive 'doing' of qualitative research & researcher's answers

Please note – all of these question were answered in Chapter 4 research methodology – this can be considered methodological reflexivity, but reflective practice already declares research bias, onto-epistemological viewpoints & so forth to answer the RQs. Hence, are these questions reflexive versus reflective?

Methodological & method reflexivity questions	
Reflexivity questions	**This researcher's answers**
What research methods is/are used?	Qualitative. I explained research methods in Chapter 4 & why. I explain above what I could have done differently had time allowed.
What is the purpose of the methods?	The purpose of my methods is to answer the research questions as outlined in Chapter 3 & 4.

What is the impact of the research method (s) on the research?	The impact of research method is the outcome of the study. The qualitative method is a subjective & objective impact on the RQ
What constitutes 'data'? How do I interpret the 'data'?	Data = the information I need to answer the RQs. In this instance, I attended relevant conferences, was invited to attend governmental taskforce as observer and interviewed relevant experts in both ecosystems. I interpret the data through a limited realist thematic network analysis perspective as declared in Chapter 4.
What data do I 'collect'? How do I collect & analyse the data? How do I manage 'objectivity' in the data analysis?	I collect observational & participant data to answer the research questions within the field of rural broadband in Wales. I used thematic analysis processes to analyse qualitative data. I tried to manage objectivity by capturing In Vivo responses & salient points. Pragmatic approach to research methodology.
What data have I chosen to include & to leave out in my presentation of findings/interpretations?	I chose the most salient points to answer the RQs as explained in Chapters 4 & 5. I left out data that was not part of this remit.
Self-reflexivity questions about researcher motivations	
Why am I undertaking the research topic I have selected?	Swansea iLab & BT Microbusiness Project started the process. I wanted to do a PhD, study more about the digital revolution, develop critical thinking & highest level of analytical skills. It is both subjective to my personal/individual learning & objective to BT/Swansea University as sponsoring entities.
What are my personal motivations? What are my personal & political reasons for undertaking my research? What personal experiences do I have related to my research topic?	I observed the 'digital revolution' in London when I was exposed to Xero accounting software & how quickly the world was changing. People could run a business on their mobile phones.
What (or who) has prompted the research & why? How is the research shaped by my own personal interest and, if applicable, the interests of the sponsoring organisation? Has this influenced the framing of the research question & the context in which the research is carried out?	BT as sponsoring organisation – wanted research on microbusinesses. Framing of research question was based on problem area analysis, but BT confirmed the RQ. The Swansea iLab project focused on Superfast Cornwall reports & this had an influence on this research. It was the origination of the project.
What is the motivation for undertaking this research? How am I connected to the research, theoretically, experientially, emotionally? And what effect will this have on my approach?	My interests - Rural broadband matters – it's not emotional, but practical; not theoretical but experiential. Want to communicate & work remotely = simple.

Self-reflexivity questions about researcher Role, Identify & Power Relations with others	
What role do positionality, identity & power play in the process of knowledge production?	Positionality - my expected role is to deliver a PhD & answer RQs to the best of my ability for BT, Swansea University & myself as academic researcher. Identity & power – infers if race/gender/class made meaningful impacts on this research? The answer is no. I might have considered male/female responses to the questions, but 'creating' gender biases from experts in the field was not the focus of this study. The research participants were interviewed because of their position/expertise and the role they occupied to answer my questions. There is no race & power or class considerations that influences or are required for this research. The goal of this research is to get a product to a final few market.
What is my power relationship with the people I am researching?	I have no power. I am an observer & interviewer. A student researcher seeking to acquire information relevant to answering my research questions. All interviewees are mature adult professionals in their field. They have the power to grant or deny access & so forth.
Am I researching with or on people?	Both. I am with them physically (observations = with) and my research involves the answers to their thoughts (interviews = on).
How does the relationship between the researchers (& the research participants) influence the research?	I suppose it comes down to my ability as a researcher to make them feel comfortable & trusting me enough to share openly & honestly. You could say my friendliness, openness & professional background has helped achieve this, but you would need to ask the participants. As stated in chapter four methodology. My ability to ensure a comfortable & trusted environment will influence the research in a positive manner. I expect the reverse would too. Ultimately, it's my research, so it's my subjectivity & objectivity to extract relevant data to answer the RQs.
Questions about Voice	
Who speaks, if natural facts & social groups are unable to speak for themselves?	In my case, they can all speak. My research participants are mature adult professional & experts in their field. They all speak for themselves.
Who is 'author'? Whose is the reflexive voice – the researchers and/or the subjects? How can we recognise the interplay of voices without privileging ourselves & excluding the voices of others?	Both - myself & the research participants. I am ultimately the author because I am writing the thesis. However, In Vivo coding was used to capture participants responses & reflected throughout Chapters 5 & 6. No voices were excluded because this was a product to market inquiry. It is not a sensitive psychological research inquiry (e.g. abuse in children or any other emotionally sensitive topic).

Can I speak authentically of the experience of the Other? If so, how?	Yes – through In Vivo coding of the interview transcripts.
How do I make sense of the lived experience of others? What are the consequences of making sense of and speaking for others? Whose voices does this sense-making exclude?	Lived experiences of others? I can't. This is not the focus of this thesis. I can only ask questions, so my questions had better be in line with answering my thesis RQs. This is not an anthropological study. What are the consequences of speaking for others? It could be misinterpretation or misrepresentation but that is the challenge of qualitative research. Hence, the bias, philosophy and thematic analysis disclosures. What voices does this sense-making exclude? People I didn't interview. I would have liked to interview more experts if time had allowed.

O.3 Table - Reflexive 'evaluating' & researcher's answers

Reflexive questions about criteria (or criteriology)	**This researcher's answers**
How do I put into practice reflexive techniques & address methodological issues in a way that results in valid, good-quality social research?	This seems to be a moot point for my thesis. Chapter Four Research Methodology has already added reflective or reflexive practices to disclose my research bias, philosophical approach & choices I have made and why. I have explained in detail my motivations, BTs as sponsor, the practical aim of this research to get a product to final few. The above 'reflexivity' exercise, for this thesis, did not add anything more to address 'valid, good-quality social research'. I think 'reflexivity' in this instance is better suited to more emotionally sensitive studies or anthropological studies & so forth. My role, positionality, identity, race/gender/class & power are not significant issues in this research project.
How can I engage in reflexive 'theorising' & 'explanation'? What is 'useful' knowledge & how can I produce it within a reflexive frame?	Again, this is a moot point. Reflexive 'theorising' is attempting to steer me into discussions over identity, gender/race/class & power discussions that are not relevant. What is 'useful' knowledge in this thesis – to answer the research questions & add new findings to the digital divide dilemma. Do I need a specifically constructed 'reflexive frame' to do this versus regular 'reflective' practises throughout my research. I would say no. I have gone to great lengths to keep the focus of this research on the AIM which is to get a product to final few market. If this study wanted to investigate if gender roles play a part – this is an entirely different study.

	Race doesn't come into this discussion. Powerplays can be a part of this discussion regarding cultural or political parties, but that is another research topic which I have already addressed why I chose the four-fold capitals and not the seven-capitals identified by Flora. Research needs a topic & focus in order to provide answers to questions & add knowledge to the problem area. My biases and philosophical approach had already been declared, so not sure how 'reflexivity' versus 'reflective' research practices are relevant in my circumstance.

In conclusion, Corlett & Mavin (2018) express the 'concern' with excessive reflexivity is that it can detract from the research aim and matter at hand (e.g. how to get a product to final few market) and reduce this research practice to paralysis, lead to self-indulgence and narcissism (p. 21). As shown throughout this thesis, reflecting on a valid research aim and questions (e.g. how to resolve rural digital divide), methods to answer the research questions and subsequent data analysis through a pragmatic and 'In Vivo' responses to reflect participant feedback more accurately (as experts in the field) is reflective/reflexive in nature. Reflective and reflexive being synonymous in most cases if race/gender/class/power are not the focus of inquiry. As outlined above in answering specific 'reflexivity' questions in business management context (e.g. thinking, doing & evaluating reflexively), it is this researcher's assertion that 'reflexivity', in this instance, has not added any value or additional analysis that was not already provided for throughout this thesis. Hence, reflecting on my biases, philosophy and so forth was sufficient to bring forth new knowledge contributions to the field of how to bridge the digital divide in Wales.

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