The impact of Technium on the knowledge economy of South West Wales.

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The Impact of Technium on the Knowledge Economy of South West Wales

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Abstract

This thesis investigates the impact of Technium in the development of the South West Wales Knowledge Economy. The Technium South West Wales network comprises of a set of business incubation and innovation Centres supporting enterprise in a range of high-growth sectors. The thesis acknowledges that Technium is a long-term initiative and the most meaningful benefits will follow in the future. However, it provides an understanding of the initiative's impact to date and how it is placed to support future development of the Knowledge Economy.

Other studies examining the impact of incubation and science parks have traditionally focused on either economic impact or the development of the resident companies. This thesis investigates both aspects, together with the role of Technium in a Sub-Regional Innovation System.

The economic impact aspect of the study examined Technium from its inception in 1999 through to 2008 when all Centres in the South West will be operational. It was found that the initiative has provided significant benefits to the region. Whereas previous studies had only examined job creation in tenant companies, this thesis presents how Technium has delivered a range of economic impacts during the construction phase and in subsequent operation.

With regard to the development of innovation and knowledge-based enterprise, a survey involving questionnaires and interviews amongst Technium companies and other firms in the wider community has shown the relative performance of companies supported by the initiative. It is shown that Technium companies are growing faster, innovating more intensely and are engaged more strongly and extensively in networking and collaboration.

The wider role of Technium has been investigated in a broad study of the regional Knowledge Economy. It is shown that the initiative is a component in a Sub-Regional Innovation System, linked with a variety of stakeholders in public, private and educations sectors.

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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STATEMENT 2

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Of course, my most heartfelt thanks are extended to my parents and girlfriend, whose ongoing support has brought me to this stage and made this study possible.

1. Introduction

1.1 Purpose of the Study

Technium is an initiative which aims to support the development of the Knowledge Economy in South West Wales. The purpose of this study is to evaluate the role and impact of Technium in this endeavour. The following sections introduce the Technium concept, and the study which follows in this thesis.

1.2 Technium

Technium is a pan-Wales initiative to support the development of a vibrant Knowledge Economy. The concept is based around a network of Centres across Wales to support growth and innovation amongst resident knowledge-based businesses. The initiative has its origins in a joint project between the University of Wales Swansea and the Welsh Development Agency (WDA) (which has since been merged into the Welsh Assembly Government, WAG). This initial project established a business incubation facility in Swansea Docklands with the mission to support a range of knowledge-based enterprise in the region. Established in 2001 with the support of public, private and education sector stakeholders, the first 'Technium' Centre was soon full.

Following this success, WAG and other regional stakeholders, with the assistance of Objective One funding[1], took upon themselves to emulate the accomplishment, developing over the following years a network of Centres, many with a specific sectoral focus. These Centres stretch across Wales from Pembrokeshire in the West to Baglan, Bridgend and up through Aberystwyth to Bangor and St Asaph in North Wales. However, the focus of this study is the group of Centres in the South West of Wales, as presented in Fig: 1.1, which has been developed in partnership with the University of Wales Swansea. Each of these Centres is described in Chapter 4.

[1] Objective One Funding was regional aid provided by the European Community. See also Chapter 2

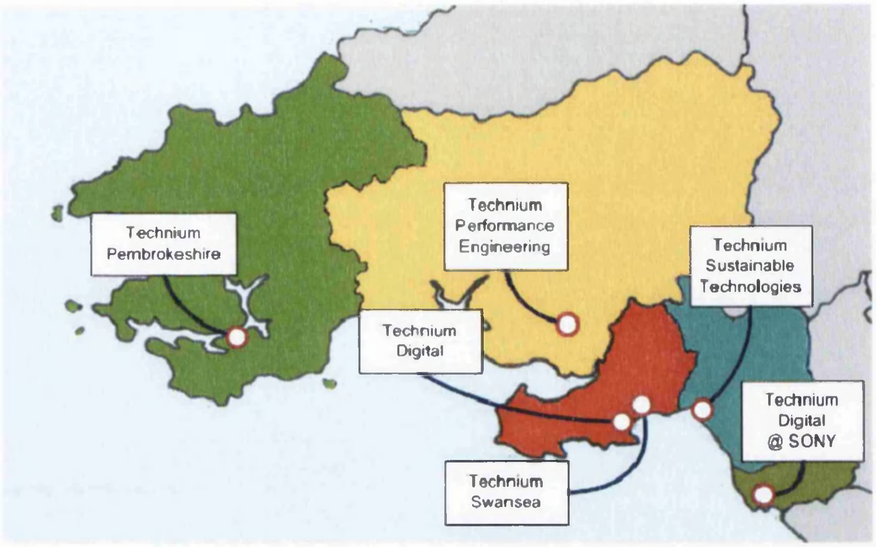


Fig. 1.1 Technium Rollout in South West Wales

While many of the Centres have been developed to support specific growth sectors identified by WAG, the underlying concept remains the same and is based on the model shown in Fig. 1.2. Based on the idea of an 'amplifier', the inputs to Technium are Knowledge Businesses and knowledge (from a variety of sources including academia, inward investors etc.), which are then developed in Centres which co-locate the businesses with specialist support and facilities.

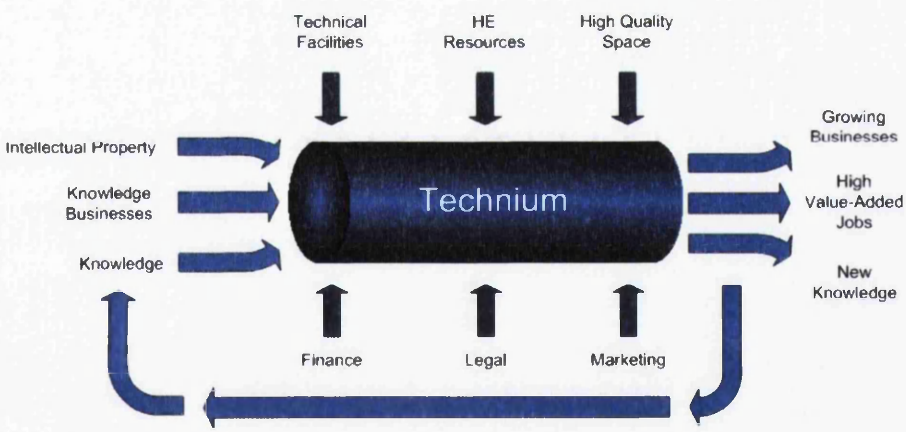


Fig: 1.2 Technium Concept

However, the ambition of Technium is '*to incubate the Knowledge Economy in South West Wales*' (Technium 2005), making it far wider-reaching than the traditional concept of business incubation. An example of this wider role can be seen in the type of companies within the Centres. Not only does Technium house and support start-ups, but it also provides a location for inward investing knowledge-based enterprise.

1.3 Wales and the Knowledge Economy

The Knowledge Economy as described by the DTI (2004) as:

"*...one in which the generation and exploitation of knowledge has come to play the predominant part in the creation of wealth*"

However the Welsh economy has its roots, not in knowledge-based sectors, but in heavy industry, manufacturing and agriculture. The Welsh coal and metal industries declined throughout the twentieth century, giving way to a wave of inward investment, primarily in the form of 'branch plant' assembly facilities, attracted by a dependable workforce, access to key markets, and all importantly – relatively low wages.

However, globalisation is placing increasing pressure on Welsh manufacturing and its other traditional sectors. This has led Wales to look elsewhere for its future economic development, and ultimately to the Knowledge Economy, for future prosperity lies in Wales' ability to innovate and be entrepreneurial in a global market. This leads back to the role of Technium, for it is through development of knowledge-based enterprise that Wales looks to prosper.

1.4 The Impact of Technium

Even though Technium is still in the early stages of what is a long-term initiative, it has already created much interest in its activities from academic and other observers. Cooke and Clifton (2005) have described the initiative as '*overambitious*', while others such as Bristow et al. (2007) have questioned its cost compared to the benefits it provides. Others describe Technium in a more positive light, including Abbey et al. (2007) who discuss its role in a 'Sub-Regional Innovation System, and the Centre for Strategy and Evaluation Services (CSES 2006) who, in a recent global competition amongst incubators, found Technium to be one of the best value initiatives of its type; in the world.

However, despite these apparently contradictory views, there is unanimity amongst these observers in one regard; they all acknowledge a more detailed study is required to understand the impact of Technium. This study aims to start the development of this understanding by examining different perspectives of Technium. Described below are the three thrusts of this study which have been undertaken to achieve this:

Economic Impact

Much of the interest in Technium (CSES 2006, Bristow et al. 2007) has related to its economic impacts and the return to the region on the investment made in the initiative. Though the meaningful economic impacts are expected in the future the question remains as to what impacts Technium has had to date. This study examines a range of economic impacts created by the initiative including:

- Employment during the Construction Phase
- Creation of valuable assets for economic development
- Employment within companies in the Centres
- Indirect support of further employment in the community
- Rental income from companies resident in the Centres

To assess these impacts a framework has been developed, based upon relevant guidance from EU and UK government, and which addresses uncertainties in this type of analysis.

Developing Knowledge Enterprise

The main goal of Technium is to support the development of knowledge-based businesses in its Centres. To assess whether this goal is being achieved, this study has undertaken a survey of Technium companies using a questionnaire and interview approach developed specifically for the task. In order to establish whether Technium is creating companies that grow more quickly and innovate more intensely than other companies in the community a parallel survey was undertaken amongst a 'Comparison Group'. The survey investigated whether Technium had an impact in creating;

- Enterprise which would not have been created otherwise, or at least not within the region
- Higher growth rates of companies assisted
- Higher levels of innovation amongst assisted companies
- A larger proportion of higher levels skills being retained and attracted to the region
- Greater company engagement with academia to exploit knowledge
- Greater intensity of networking and collaboration in terms of scope and geography

A Sub-Regional Innovation System

The third strand of this study explores the concept of Technium as a component in a Sub-Regional Innovation System, as introduced by Abbey et al. (2007). The study examines the behaviour of Technium companies in light of the 'characteristics' of a Sub-Regional Innovation System including;

- Development of local knowledge networks
- Development of extra-regional links
- Large corporations externalising R&D functions and developing links with academia

2. A Brief History of Economic Development in Wales

While Technium is a relatively new initiative, many of the challenges it aims to address are the product of a turbulent regional economic history. These challenges include not only worldwide phenomena such as globalisation and the emergence of the Knowledge Economy (discussed in Chapter 3), but also an industrial and social legacy that leaves Wales with a relatively weak economic base. Due to this, Wales has many sectors in decline or facing intense pressure from overseas competitors, where low wages make activities such as manufacturing cheaper.

The following sections chart the economic history of Wales, tying it in with the various instruments applied by European, UK and Welsh governmental layers to support economic development. This brief history is discussed in the context of the accompanying political upheaval.

2.1 The Industrial Revolution

While the industrial revolution is often associated with certain technological advances the concept stems not from adoption of a particular invention, but rather from the start of a massive economic restructuring that saw the United Kingdom established as the world's first industrial nation (Mathias 1983). This restructuring saw the migration of economic activity from agriculture to industry and the migration of the workforce from the countryside to towns and cities (Stiglitz 1999). While agriculture started to become mechanised production industries such as textiles, iron and steel became drivers of economic growth.

However, these industries were not the preserve of manual unskilled labour. 'Skilled' workers were required to sign legally enforceable contracts that would prevent them taking their knowledge elsewhere if they received a better offer (Ross 2005). Though this would not relate to circuit layouts in microelectronics or recombinant DNA, it was an early example of practice we now see as common in our modern 'Knowledge-Based' economy.

The growth of the Welsh economy was however to be boosted by the great innovation of the industrial revolution; the steam engine (Ross 2005). The great impact of this was not in making the process of mining more efficient but in providing a global market for Welsh coal to power the steamships and locomotives of the British Empire.

However, as the term revolution implies, this massive industrial growth was not sustained and this led to massive economic and political upheaval in Wales. Despite industrialisation around the world, various factors combined to reduce the scale of the Welsh coal industry long before its eventual collapse in the 1980s. This came about due to a variety of factors including modernisation of industries in competing nations such as Poland, service of overseas markets by closer competitors (such as Canada importing coal from the United States), and even the war reparations enforced on Germany, which lacking cash were settled in coal (Morgan 1981).

2.2 *Industrial Decline and the 'FDI' Era*

2.2.1 Overview

The massive contraction of the steel industry and the almost complete disappearance of the coal industry during the 1970s and 1980s punctuated a trend of economic decline that had set in during the post-war period (Morgan 2001). To stem this decline, major efforts were made to develop other sectors, including attracting Foreign Direct Investment (FDI) (which is discussed in the next section). Since the 1970s this restructuring has absorbed 200,000 jobs from these declining industries into a more modern base of services and manufacturing (WAG 2001). This was also accompanied by a gender restructuring of the workforce that included the proportion of women rising from 38% in 1975 to 50% in 1994 (Cameron et al. 2002).

The GDP of Wales has broadly tracked that of the UK as a whole, though trailing somewhat behind, since records began at the beginning of 1970. This lagging performance, is an effect of the structure of the Welsh economy relying heavily on low value-add employment, compounded by higher rates of economic inactivity in Wales (and particularly the West Wales and Valleys region), along with lower productivity per employee as shown in the table below (WEFO 2004).

Industrial Sector	**1996 GDP per employee, ('000s)**	
	Wales	**UK**
Agriculture, Hunting, Forestry and Fishing	12.8	22.6
Mining, Quarrying including Oil and Gas Extraction	55.1	60.0
Manufacturing	33.9	32.8
Electricity, Gas and Water Supply	98.2	105.7
Construction	18.9	20.9
Wholesale and Retail Trade	22.4	25.0
Transport and Communication	30.6	35.1
Public Administration and Defence	20.4	26.1
Education, Health and Social Work	17.6	18.2
Other Services	5.3	4.7
Total	**22.8**	**25.1**

Table 2.1: GDP per employee by sector, Wales and UK, 1996 (WEFO 2004)

2.2.2 The Welsh Development Agency and 'The Field of Dreams'

This massive economic pressure and the rise of nationalism led to the UK government establishing development agencies in Wales and Scotland in 1976 (Cooke and Clifton 2005). In Wales this took the form of the Welsh Development Agency (WDA). Its core strategy to provide job creation was to pursue Foreign Direct Investment (FDI) from around the globe. Though much of the literature mentioned in the following section focuses upon FDI in the UK and Wales, it should be noted that this phenomenon of economic development through FDI occurred throughout the European Union (EU) and Organisation for Economic Cooperation and Development (OECD) (Barrell and Pain 1997), including the United States (Friedman et al. 1992). However, FDI interventions occurred at (proportionally) higher rates in the EU than the OECD, which were higher in the UK than the EU, and higher in Wales than the UK as a whole.

The prime hunting ground for such opportunities was the 'Tiger economies' of South-east Asia and the following decades would see names such as Panasonic, Sony and LG all establish operations in the region, mainly of an assembly nature. The attraction for these investors included access to markets, low wages and other financial incentives. Access to markets is seen as a key factor in the location decisions of FDI as discussed by various observers, for example, the increase in FDI in Spain following its joining of the EU (Young et al. 1997, Friedman et al. 1992). This has now become a challenge for older EU regions in competition with the newly joined countries of Eastern Europe.

However, the prizes of attracting FDI, which could bring thousands of jobs at a time, were massive. This often led to interregional competition for investments with packages of aid being offered including grant aid, assistance with planning issues etc. (Phelps and Tewdwr-Jones 2001, Cooke and Clifton 2005). Alongside these packages, however, was what often figured as the key determinant in attracting FDI (in both Wales and other regions); a low wage rate (Friedman et al. 1992).

The WDA proved to be most successful at this competition, securing over two thousand projects between 1983 and 2000 (Salvador and Harding 2005), consistently attracting between 15-20% of FDI coming to the UK between 1983 and 1993 (Cooke 1998). One major investment could deliver massive opportunities to the surrounding region and much like the iron works of old, would become the prime employer in a town or region (Mathias 1983). The approach of the WDA in speculatively preparing sites across Wales to attract investors was likened by some commentators to the "*build it and they will come*" concept seen in the American movie 'Field of Dreams' (Cooke 2005).

This successful attraction of FDI into Wales meant that by 1992, 30% of Welsh manufacturing employment, some 68,000 workers, were employed in foreign-owned firms compared to 45,000 just over a decade earlier in 1981; a proportional increase double that of the UK as a whole (Cameron et al., 2002).

The increase in FDI during this period led to much research to understand issues such as policies to support its role in regional economies (Gripaios et al. 1997, Young et al. 1994); its 'embededness' within the region (Phelps et al. 2003, Phelps et al. 1996); the 'quality' of investments (Gripaios et al. 1997); and their role in technological change and technology transfer (Barrell and Pain 1997).

Observers note in retrospect that this focus on inward investment may have led to the missed opportunity of investing in entrepreneurship and indigenous development that received greater attention in regions such as Scotland and Northern Ireland (Cooke and Clifton 2005).

Other criticisms of FDI include weak linkages with the regional economies within which they reside, such as supply chains (Young et al. 1994) and the 'quality' of the jobs provided, which were primarily assembly functions in branch plant operations. However, where the Multinational enterprise (MNE) is investing far from its home country the linkages it establishes are generally found to be stronger (Rodriguez-Clare, 1996). Young et al. (1994) describe strategies that can be applied to make use of MNE FDI in the development of cluster formation through creation of linkages with local R&D. Such linkages may be with universities and development of supply chain opportunities.

By the end of the century the Steel industry had suffered greatly in the face of global competition and the start of a phase of massive sectoral consolidation was set to continue into the new millennium. Meanwhile the efforts of the Thatcher government meant the coal mining industry had virtually been destroyed, leaving a very different Welsh economy to that which had fuelled the industrial revolution and transformed the entire world.

However, Wales was to face political upheaval on a scale to match that of the changes in its economy, as the subsequent Labour government promised a referendum for a National Assembly. The proposal was for an Assembly which would have responsibility for certain limited portfolios (including particularly challenging ones such as Health and Education), something not attempted since a previous referendum (also attempted by a Labour UK Government) was defeated by a margin of 80% in 1979 (Keating 1998).

2.2.3 The National Assembly for Wales

Following successful referenda on the proposals in Scotland and Wales, the National Assembly for Wales and the Welsh Assembly Government (WAG) took over control of affairs including health, education and economic development. Scotland regained its parliament, which it lost in the act of Union in 1707, providing greater control for Scots over their own affairs.

This marked a massive political change for the devolved countries and the UK as a whole, marking the greatest constitutional change in what was seen to be an ongoing process of devolution (Keating 1998) since the abolition of the House of Lords veto in 1910 and the establishment of the Irish Free State in 1921 (Morgan 2001).

Since its integration with England in 1536, Wales had long been regarded as being tied more closely with England than its northern Celtic neighbour, despite clear religious and linguistic differences (Keating 1998). This is further reflected by the Welsh Office having only existed since 1965, while Scotland had enjoyed such representation within Westminster since 1885. This is seen, along with a perceived lack of consensus amongst the Welsh people for devolution, as one of the reasons for a lower level of power being devolved to Wales (Salvador and Harding 2005).

The 'Assembly' itself is a body that encompasses the legislative functions (National Assembly for Wales) and the executive functions (WAG). The legislature comprises 60 elected members representing constituencies and regions. Much of the power of the Assembly is held by the First Minister who appoints a cabinet of Ministers to hold portfolios including Education, Health, Culture, Local Government, and Economic Development and Transport. This structure is shown in Fig. 2.1, cited from Salvador and Harding (2005). However, the level of devolved power given to the Assembly is far less than that afforded to Scotland and this is cited by some as a debilitating factor in the Assembly's ability to deliver economic revival (Cooke and Clifton 2005).

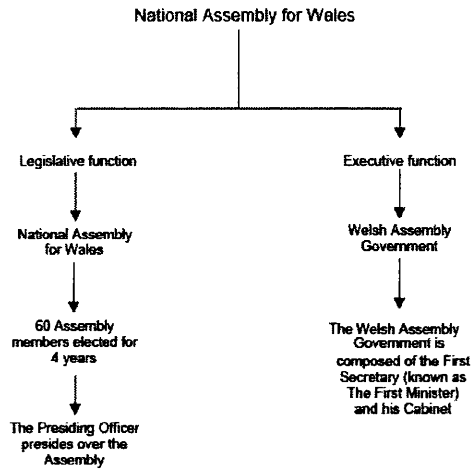


Fig. 2.1 Structure of the National Assembly for Wales, from Salvador and Harding (2005)

Funding for the Assembly is provided by the UK Government with adjustments made according to the Barnett formula that effectively sees Wales receive 6% of UK funds, roughly in line with its proportion of population. This mechanism is however seen by many, including its creator, as a badly designed formula in desperate need of replacement that has operated to the detriment of Wales (McLean and McMillan 2003). However, it should be noted that recent years have seen additional funding from the UK Treasury in reflection of support it is receiving from EU Structural Funds (Salvador and Harding 2003), which itself represents an important source of funding. However, this represents only 1% of the annual Assembly budget (Brooksbank et al. 2001).

In terms of economic development the Welsh Development Agency was now accountable to a Cardiff based minister, rather than the Secretary of State for Wales at the Welsh Office in London. The budget for economic development and transport in 2005-06 totalled just under £1.5bn, or 12% of the total Assembly expenditure. It should though be noted that this includes a significant portion for transport. Approximately £120m p.a. has been allocated for 'Innovation and Competitiveness' with a further £80m p.a. for 'Entrepreneurship' (WAG 2005).

Much commentary and study has been of this transition, often in comparison with the 'settlements' in the other devolved regions of the United Kingdom (Morgan 2001, Salvador and Harding 2005, Cooke and Clifton 2005), as a new level of politics was introduced to Wales. Some observers argue the asymmetric settlements have led to varying outcomes for individual regions (Cooke and Clifton 2005), while others such as Morgan (2001) describe the risk of highlighting regional inequalities and developing interregional rivalry rather than co-operation. The observations of Cooke and Clifton (2005) are of particular relevance to this study. They argue Technium is an 'overambitious' initiative and a return by the Assembly to the 'Field of Dreams' approach as part of a 'precautionary' approach to economic development.

2.2.4 Key Strategies of the Welsh Assembly Government

Economic Development

A Winning Wales, and Wales: A Vibrant Economy

The Welsh Assembly Government outlines its overarching strategic agenda in 'Wales: A Better Country' (WAG 2003b) with policy areas including;

- *Helping more people into jobs*
- *Improving health*
- *Developing strong and safe communities*
- *Creating better jobs and skills*

This agenda ties together the policy areas of health, education, transport, local government and economic development.

The economic development agenda is captured in 'A Winning Wales' which was first delivered in 2001 (WAG 2001), updated in 2003 (WAG 2003a). It is supported by a host of interrelated strategies and accompanying action plans for aspects of economic development including innovation (WAG 2003), entrepreneurship, skills, (WAG 2005c), the environment and specific industry sectors. The Strategy also aims to outline how Structural Funds, including Objective 1 funding are to be used in economic development for West Wales and the Valleys.

Fig. 2.2 A Winning Wales and associated Action Plans, from Wales for Innovation (WAG 2003)

The strategy is built around a vision that clearly reflects the ambition to develop a strong and vibrant Knowledge-Based economy in Wales;

"To achieve a prosperous Welsh economy that is dynamic, inclusive and sustainable, based on successful, innovative businesses with highly skilled, well-motivated people"

(WAG 2001)

To realise this vision the strategy (WAG 2001) outlines the key targets, again reflecting the agenda of a knowledge-based economy;

- *raising total employment by 135,000*
- *improving enterprise and innovation*
- *raising not just skill levels but learning performance at every level*
- *ensuring Wales uses world-class electronic communications to their full potential*

In order to achieve these, the Strategy outlines key requirements including;

- *Improving rates of new business formation*
- *Addressing under representation of rapidly growing sectors such as financial and business services*
- *Building upon strengths in key sectors including aerospace, opto-electronics and automotive*

In 2003 WAG published an Annual Report (WAG 2003a) on the progress towards fulfilling the vision of 'A Winning Wales' (WAG 2001), prior to delivering an updated version of the strategy in 2004 (WAG). This reinforced the WAG objective of bringing the prosperity of Wales to 90% of the UK level within a decade and in line with that of the UK within a generation.

'A Winning Wales' has also been recently supplemented by Wales: A Vibrant Economy' (WAG 2005b) which presents WAG's 'Strategic Framework for Economic Development'. This further reinforces the agenda of the Knowledge Economy, with specific regard to the West Wales and the Valleys region, with its focus on;

- *Promoting the knowledge economy, by fostering research, technology and innovation, building a stronger entrepreneurial environment, supporting the development of clusters/centres of excellence in key sectors and improving access to business finance.*
- *Improving skills levels, both as a means of tackling innovation and providing the skills for higher value-added employment. This will include supplying young people and new entrants to the labour market with the skills needed to in turn develop the skills and qualifications needed for more senior jobs in the economy.*

Wales for Innovation - Innovation Action Plan

The Innovation Action Plan aims to set out how innovation can be fostered in Wales to help deliver the Knowledge Economy aspired to in 'A Winning Wales' (WAG 2001). Actions proposed by the plan consist of five groupings namely;

- Communicating what can be achieved through more innovation
- Developing more high growth potential businesses
- Better equipping people to innovate
- Simpler, more accessible, business innovation support
- Maximising the economic development impact of our universities and colleges

Core to the Plan is the further development of the 'Technium' initiative where the plans for this pan-Wales network were described with a pledge to invest "*up to £150m...rolling out across Wales, ...*[to] *act as innovation focal points within their regions*".

The plan also describes how innovation and skills are to be supported through programmes such as the Technology Exploitation Programme (TEP) and SMARTCymru[2]. It also describes how this would be achieved in conjunction with other WAG bodies including the Higher Education Funding Council for Wales (HEFCW) and Education and Learning Wales (ELWa).

A Science Policy for Wales

The recently launched Science Policy for Wales (WAG 2006) underlines the importance given by WAG to the Knowledge Economy in the future of the country, citing the vital role of science, engineering and technology. Three key priority areas were identified for focus of support and resources of;

- Health / life sciences
- The low carbon economy
- Sustainable economic and social regeneration

The policy recognises the potential for enterprise developing from scientific endeavour in Wales, though recognises fundamental challenges including the relatively low intensity of scientific research within the country and the low level of Research Funding Council resources won by

[2] SMARTCymru is a WAG initiative created to support the development of new products and processes

Welsh HEIs. This is reflected in much of the evidence supplied to the review that preceded the policy (NAW 2006). However, the Policy does also acknowledge that Wales is a small nation that could not and should not aspire to the breadth and depth of science activity in which much larger territories have the resources to engage. It is though recognised that despite this, scientists and engineers working in Wales will be working in their specific fields with science of the highest quality on national and international stages.

Commercialisation of science and innovation is also addressed by the Policy with Technium being cited as a key initiative in developing enterprises built around science and technology, with the aspiration of creating science parks '*under the Technium banner*' to provide an infrastructure that will facilitate economic growth within Wales.

The Wales Spatial Plan

Spatial Planning refers to the methods used by the public sector to plan activities within a space and has been used extensively in the European Union for planning within regions since 1984 (ESPON 2007). '*People, Places, Futures: The Wales Spatial Plan*' (WAG 2004c) represents WAG's vision of future development across Wales. The vision encompasses all aspects of future development including transport, health, education and economic development. The planning process examines Wales in the context of six distinct regions as shown in Fig.2.3.

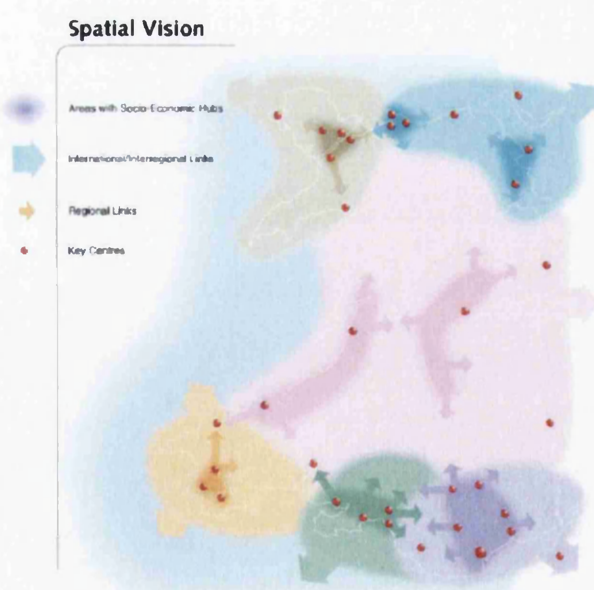


Fig. 2.3 Regions of Wales according to the Wales Spatial Plan Vision (WAG 2004)

The Technium centres of South West Wales fall within the spatial planning regions of '*Swansea Bay, Waterfront and Western Valleys*' (shaded green in Fig.2.3) and '*Pembrokeshire*' (shaded orange). Each region has a specific plan representing its own situation.

The economic vision for Wales described in the Wales Spatial Plan highlights the importance of the Knowledge Economy with focus upon the provision of opportunities that harness the skills and knowledge of the people:

"We need an innovative, high value economy for Wales which utilises and develops the skills and knowledge of our people: an economy which both creates wealth and allows that prosperity to be spread throughout Wales: an economy which adds to the quality of people's lives as well as their living and working environments."

Wales Spatial Plan, 2004

To achieve this vision, the plan lays out the need for engagement between public, business and other partners. It presents a range of actions for the region and Wales as a whole including taking forward of strategies such as the Skills and Employment Action Plan and Creative Industries Strategy along with investment in knowledge transfer initiatives such as Technium.

As part of this Spatial Planning Exercise overseen by the Welsh Assembly Government each region must select and develop themes for its future development.

In line with the Lisbon Agenda of the European Union, the region of Swansea Bay, Waterfront and Western Valleys is focusing on building upon its Knowledge Economy foundations to provide a prosperous and sustainable future for its communities. This embodies in the vision for the region described in the Wales Spatial Plan. The charge to develop the Knowledge Economy described in the Plan makes direct reference to the roles of both Swansea University and Technium;

- Retaining young people and attract well-qualified people from outside the area to provide a stimulus for improved economic performance.
- The University, FE Colleges and Technia should embed the Knowledge Economy within the area.

2.3 The 'Objective One' Era – 1999-2006

2.3.1 The Continuing Challenge

Wales entered the new millennium equipped with a new Assembly to fulfil its ambitions, but much like its devolved neighbours of Northern Ireland and Scotland was about to attempt this in the face of economic decline, poor conditions for entrepreneurship and the disinvestment caused by globalisation (Cooke and Clifton 2005).

The scale of this challenge is highlighted by the fact that Wales, with 5 percent of the UK population, only contributes 4.5 percent of total economically active persons and 3.9 percent of GDP in the UK. The Welsh Assembly Government has set itself the target of closing the gap with the rest of the UK economy by raising per capita GDP to 90% of UK levels within a generation (WAG 2001). This target is an enormous aspiration which would require national economic performance to be raised to a level not seen in a century (Crafts 2005). This is shown in Fig. 2.4 presented Crafts recently to a conference in Cardiff.

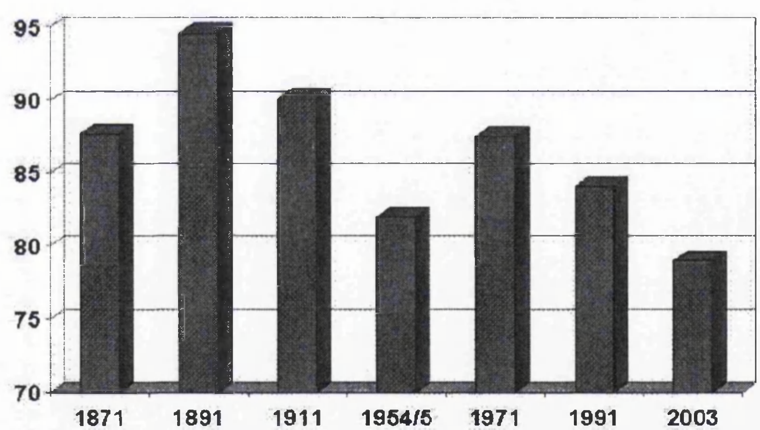


Fig. 2.4 GDP/Person in Wales as % of Great Britain GDP, selected years (Crafts 2005)

The pressure on manufacturing and basic industries continued with the closure or relocation out of Wales of many inward investors and the termination of steel production at Llanwern. In the period between 1998 and 2003 Wales as a whole lost 57,000 manufacturing jobs. This has again raised the question of how 'embedded' multinationals are (or were) in the Welsh economy, with the suggestion that the presence of functions beyond assembly such as research and development would improve embededness (Phelps et al. 2003).

In addition to the continued pressure on manufacturing, the supply of FDI opportunities available was starting to fall during the end of the 1990s due to a slow-down in the global economy (Young et al. 1994) and the emergence of new attractions for FDI, most notably in China and India (Chen 1996). Despite the emergence of these low cost competitors it is observed that wage rate versus skills level remains an issue, working in favour of the relatively better skilled workforces of developed nations (Wei et al. 1999).

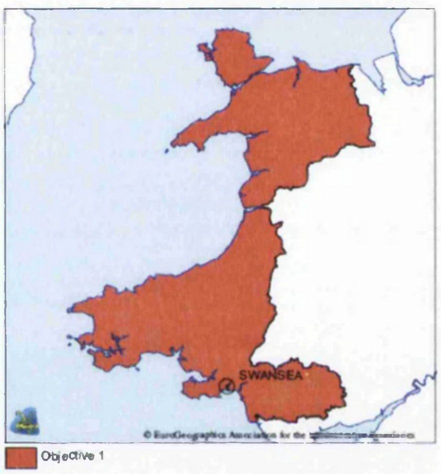
Furthermore another factor which also hampers future growth for the region is an aging population, which though not a unique regional challenge, does feature worse than for the country as a whole (EU 2005).

These challenges meant the problems of the new millennium would not be fixed by the same solution of solely attracting foreign investment by cheap labour and access to markets used at the end of the last century.

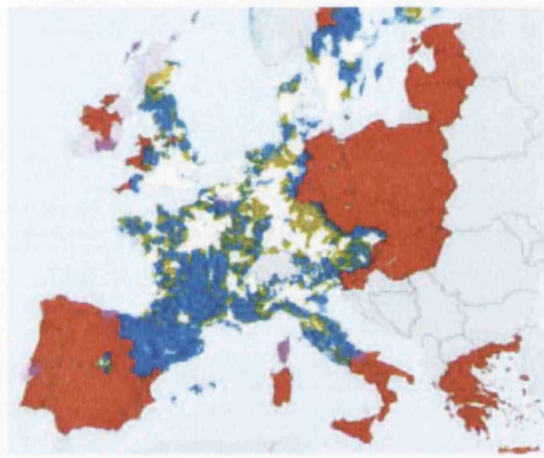
2.3.2 Objective One

Rationale

At the end of the twentieth Century much of the Welsh economy was trailing significantly behind, such that GDP was only 73% of the European average (WEFO 2004) meaning that parts Wales qualified for 'Objective One' assistance. This level of assistance represented the highest level of aid provided by the EU and was targeted at regions with GDP below 75% of the EU average.



Objective One areas in Wales
(EU 2004)



Objective One regions in the EU
(EU 2004a)

Fig. 2.5 Objective One Areas in Wales and the EU

The fact that not all of Wales qualifies for such assistance reflects the variation in prosperity across the country. This is highlighted by the fact that disposable incomes in the Vale of Glamorgan are as high as those in the more affluent parts of Bath and Bristol across the bridge, while the mining communities of the Valleys just a few miles from the other side of the M4 remain as impoverished as the most deprived parts of Inner London (Lovering 1999).

The reasons for this poor relative performance were structural dependence upon low value added activities, low productivity in certain sectors and high levels of unemployment within an overall low level of economic participation. Objective One funding came about thanks to the creation of a new statistical region 'West Wales and the Valleys' that presented and highlighted the economic woes of this part of Wales (Cameron et al. 2002).

Funding

The value of this assistance totalled some £1.2bn in grant aid – to be match funded from other sources. Brooksbank et al. (2001) discussed a potential risk of removing European funds from the 'block grant' received under the Barnett formula in endangering 'bottom-up' approaches to economic development, as other funding sources needed to be levered for match funding. However, this decoupling is a requirement imposed by the European Community to ensure 'additionality' and prevent governments from displacing other expenditure with this type of funding. This match funding requirement aims to develop joined up policy and the assurance of value.

The Objective One goals of increasing national GDP from 73% to 78% of the UK average, mainly by providing 43,500 extra jobs and reducing the number of economically inactive by 35,400 were regarded at the outset as ambitious (Brooksbank et al. 2001).

The aims and strategy for using this funding to achieve this ambition were embodied in the Single Programming Document (SPD). This was developed by the Welsh European Partnership and the National Assembly for Wales (WEFO 2004). The SPD outlined plans for the economic, social and environmental regeneration of West Wales and the Valleys during the period 2000-06 using the European Regional Development Fund (ERDF), the European Social Fund (ESF) and other funds relating to agriculture and fisheries.

- Priority 1 – Expanding and Developing the SME Base
- Priority 2 – Developing Innovation and the Knowledge-Based Economy
- Priority 3 – Community Economic Regeneration
- Priority 4 – Developing People
- Priority 5 – Rural Development and the Sustainable Use of Natural Resources
- Priority 6 – Strategic Infrastructure Development

The greater focus on the development of the SME base and nurturing of indigenous innovation represented a shift away from FDI. A critical event in stimulating this shift was the infamous LG project, which was questioned at its outset for the demands it put upon regional capacity and linkages with local service providers (Phelps et al. 1998). While the LG project was perhaps overambitious at a time of intense technological and economic change, it should be noted that much of the government investment was recovered (WAG 2004a) and a slightly less ambitious project developed for the LG site.

The scale of this shift in policy was to be truly massive, as investment in the innovation in the indigenous SME base at the end of the last Century had only totalled £4m annually of a £400m spent on supporting development, industry and training programmes in Wales as a whole (Brooksbank et al. 2001).

Management of the Funds

Allocating the £1.2bn of European funds and managing frameworks of numerous projects was a major challenge for the Welsh European Funding Office (WEFO). WEFO was established as an executive agency of the Assembly Government on 1st April 2000 (Salvador and Harding 2005). Managing the funds posed such a challenge for the Welsh Assembly Government that it was estimated that the number of civil servants involved in economic development increased by 25% during the period to total 1,700 (Cooke and Clifton 2005).

Cooke and Clifton (2005) also describe problems faced in the bureaucracy around 2003 of allocating the funding. This coincided with structures for the management of Objective One being revised and the absorption of WEFO into the Welsh Assembly Government's Department for Economic Development and Transport. This restructuring involved six 'Thematic Advisory Groups' (TAGs)[3] being formed to oversee delivery of the six programmes and fifteen 'Local Partnerships' to focus on delivery of the Programme within each local authority area. (WEFO 2005).

The responsibilities of the thematic groups have been to advise on strategic priorities in the use of the Objective One funding, provide a qualitative assessment to WEFO of each project as part of the appraisal of the project and to monitor and evaluate overall delivery of the priority for which they are responsible. These groups each included about 10 members appointed through the Assembly's Code of Practice on Public Appointments (WEFO 2005), which resulted in memberships comprising of civil servants, leading academics, industrialists and other stakeholders (WEFO 2006), each with their own field of expertise and extended network.

Meanwhile, the Local Partnerships have been charged with advising applicants for funds on project development matters, assisting with implementation issues, share best practice and provide project aftercare (WEFO 2005).

[3] The Thematic Advisory Groups were: Business Support for SMEs; ICT Innovation and R&D; Community Economic Regeneration; Education Training and Skills; Rural; and Infrastructure (WEFO 2005)

Outputs of the Programme

The Objective One Programme in Wales has comprised some 2,500 projects representing £3bn of public and private investment to address the social and economic challenges which attracted the £1.2bn of EU Structural Funds (WAG 2005b).

The final quantification and evaluation of the outputs of the Programme are not yet possible because, although the Objective 1 period has come to an end, many projects are still being undertaken as expenditure can run into 2008. Examples of these include Technium Performance Engineering, Technium Pembrokeshire and the Institute of Life Science at Swansea University.

The mid-term review of the Programme, conducted during 2003, benchmarked progress towards the overall target. It found that despite most targets being in line with or superior to those anticipated, the job creation target was making slow progress. It should be noted, that at this point in the Programme, the review states many project and programme managers regarded the targets as unrealistic. These concerns resulted in the restructuring of the mechanism to manage the funds as described above (WEFO 2005).

2.3.3 Key WAG Knowledge Economy Development Tools

Described below are five of the major interventions which relate to the Knowledge Economy. These complement generic economic development tools such as Regional Selective Assistance (RSA), Assembly Investment Grant (AIG) and the Property Development Grant (PDG). It should be noted that many UK-wide innovation and knowledge-economy support mechanisms such as Innovation Tax Credits and Knowledge Transfer Partnerships (KTP) are also available to Welsh businesses.

Knowledge Exploitation Fund (KEF)

Originally managed by Education and Learning Wales (ELWa), the Knowledge Exploitation Fund (KEF) programme was passed to the WDA. It was then absorbed into the WAG along with the rest of the WDA in 2004 (see section 2.3.4 below). The Fund co-supports the assistance provided by Finance Wales in the Wales Spinout Programme.

Established in 2000, the £14m Fund was created to support and develop entrepreneurship in academia through staff training, provision of scholarships and creation of '*entrepreneurship champions*' to embed a culture of entrepreneurship within institutions (WFC 2007).

Based in DEIN, the fund now offers additional support, funded from European Structural Funds including funding for Patent and Proof of Concept (PPOC) and Collaborative Industrial Research Projects (CIRP) to commercialise academic invention. Other initiatives include support for development of technology transfer centres and networks, and industrial training projects.

Intellectual Property Wales (IP Wales)

IP Wales was initiated by the School of Law (Swansea University) developed to support SMEs through better management of Intellectual Property. It also has now been absorbed into WAG. The support has consisted of helping businesses identify their IP through audits, along with provision of expertise and grants to assist in its protection and exploitation.

The initiative has enjoyed great success, providing strategic advice to 750 Welsh clients, helping turn inventions into 205 patents, protect 12 trademarks and develop 5 licensing deals by 2002. This has led to IP Wales being recognised as an example of best practice in business support by the World Intellectual Property Organisation and attainment of the Judges Special Award at the 2004 WORLDleaders: European Intellectual Property Awards.

Finance Wales

The WDA in conjunction with the Welsh Assembly Government established Finance Wales, a body charged with operating as a 'lender of last resort' providing loan and equity finance to SMEs in the Objective One area (Salvador and Harding 2005). Support is also available to companies outside the Objective One areas though offered in different packages on different terms. In addition to financing, the organisation also offers mentoring and management support (Finance Wales 2007) and manages the £7m Creative IP Fund (WAG 2005a). This fund was established as part of the Welsh Assembly Government's creative industries support strategy 'Creative Success – a Strategy for the Creative Industries in Wales' providing an example of the WAG sectoral approach being adopted for business support.

Uptake of the scheme appears to be lower than anticipated with the organisation becoming more involved in co-funding grant packages (Cooke and Clifton 2005). Cooke and Clifton 2005 also note that the use of pre-qualification for RSA as a precondition for accessing Finance Wales support may result in companies becoming more dependent upon grants and limit the number of businesses assisted. However, contrary to this supposition, the number and size of investments has increased since this observation including £10m of investments made during 2005 (IT Wales 2007).

Finance Wales is also responsible for the Wales Spin-out Programme which supports the spin-out of companies from Welsh academia. Assistance offered includes managerial support and a 'soft' loan of up to £25,000. During the period January 2000 to May 2003 the programme assisted in the creation of 55 new firms (Finance Wales 2003).

Knowledge Bank for Business (KB4B)

Launched in September 2005 (WAG 2007), the Knowledge Bank for Business (KB4B) was created to support high-growth potential companies in Wales. The bank has been focusing its efforts on an initial cohort of 50 businesses identified by the Welsh Assembly Government with assistance from the WDA and professional services firms in Wales. Criteria to qualify for assistance require an SME to demonstrate the ability to double turnover in three to four years from a base of at least £3m turnover p.a., while larger enterprises need to demonstrate '*significant growth prospects*'. By 2008 it is envisaged that KB4B will have assisted a further 100 companies (KB4B 2007).

Support provided by KB4B includes financing, training and consultancy. While the financial support offerings are the same as those available to other businesses, the Knowledge Bank 'training' and 'consultancy' offers claim to provide a higher level and quality of support than is otherwise available to the wider business community.

Technium

The Technium initiative started with an Objective Two[4] project in Swansea between Swansea Institute of Higher Education (SIHE) and the WDA to establish a business development and incubation centre. However, with the move of the proposing academic from SIHE to Swansea University, the project became based at the University. The success of this initial project has subsequently been built upon with further centres, many of which have a sectoral focus. Technium, as the focus of this study, is described in more detail in Chapter 5.

2.3.4 'Bonfire of the Quangos'

On 14th July 2004 the Welsh Assembly Government announced a major review of how public services are delivered in Wales. Subsequently, in October of that year, WAG outlined its vision for the future delivery of public services in 'Making Connections: Delivering Better Services for Wales: The Welsh Assembly Government Vision for Public Services' (WAG 2004a). The aim of this vision is to deliver greater efficiency and impact from the efforts of the Welsh Assembly Government by creating improved co-operation and co-ordination between agencies and across the public sector as a whole (WAG 2004a). A major structural change in this vision involved bringing quangos, which had previously operated with an element of independence, within the Assembly structure. Such organisations included the WDA, Wales Tourist Board (WTB) and ELWa. While the focus of the strategy is to maximise impact, the core concept of providing greater control to WAG over these bodies and activities is clear from the statement that precedes the discussion of these agencies in 'Making Connections' (WAG 2004a), as follows;

"It is this Assembly, with the authority of its democratic mandate, which must assume responsibility and accountability for public policy in Wales. It is for Ministers to determine policy, and for this Assembly to hold us to account."

Following the publication of the vision WAG spent the next six months developing an action plan, before carrying out the mergers on 1st April 2006. Certain observers were critical of this move, with some regarding it as an example of 'moving the institutional deckchairs' (Cooke and Clifton 2005).

[4] Objective 2 is the second highest tier of economic assistance provided by the EU. Prior to the 1999-2006 Objective One period, Swansea was within an Objective Two region.

2.3.5 Assembly Bodies and Agencies

The following section provides an overview of key bodies and agencies that are involved in and impact upon economic development and the Knowledge Economy in Wales, relating to Education and Skills (ELWa and HEFCW) and Economic and Business Development (WDA and WTI). Instruments of these organisations such as the Knowledge Exploitation Fund (KEF) and Technium are described separately in section 2.3.4.

The former Welsh Development Agency (WDA) and the Department for Enterprise, Innovation and Networks (DEIN)

Referred to as 'the most powerful economic actor in the West of Britain' (Lovering 1999), the WDA was the primary economic development arm of the former Welsh Office, becoming accountable following devolution to the Welsh Assembly Government's Department for Economic Development and Transport. Subsequently it became part of the newly formed Department for Enterprise, Innovation and Networks (DEIN) as part of the 'Bonfire of the Quangos' described earlier in section 2.3.4.

The WDA was established in 1976 to help stem the economic decline seen during the 1970s. While the initial focus of the WDA was to attract FDI (as described in section 2.2) this was joined by a significantly increased level of effort in supporting indigenous enterprise, particularly that which is new and/or knowledge-based, along with further integration of the skills agenda. This came about with the changing global economic conditions and the strategy of WAG (WAG 2001). The difference is clearly seen in the WDA Corporate Plan which was developed prior to its absorption into WAG (WDA 2002) where the activities of the organisation were described as being;

- *We help more businesses get started in Wales.*
- *We help more businesses grow.*
- *We help businesses become more competitive.*
- *We help communities prosper.*
- *We help create opportunities for people in Wales to develop themselves and earn more.*

(WDA 2002)

The functions of the WDA's successor, DEIN, reflect the combined economic development and transport agendas and are summarised as follows (WAG 2007a);

- *supporting job creation and helping individuals to tackle barriers to participation in the world of work*
- *investing to regenerate communities and stimulate economic growth across Wales*
- *helping businesses by supporting entrepreneurship, innovation, inward investment, trade and skills as drivers to growth*
- *ensuring that all economic programmes and policies, especially those for clean energy generation and resource efficiency, can support sustainable development*
- *building a world-class 21st Century transport system that provides affordable, environmentally friendly road, rail and air transport for business access and personal travel, especially commuting*
- *building on Wales' already formidable ICT network*

DEIN is responsible for a number of major knowledge economy initiatives in Wales including the Knowledge Bank for Business (KB4B) and the Knowledge Exploitation Fund (KEF), and is the government partner in the Technium initiative.

Wales Trade International (WTI)

The WDA had always focused overseas efforts on attraction of inward investment to Wales. In a reciprocal manner, Wales Trade International (WTI) was created with the mission of encouraging and supporting Welsh businesses in accessing overseas markets. This effort works to realise the target set in '*A Winning Wales*' (WAG 2001) to deliver '*smarter ways of connecting Wales to international business opportunities*'.

Unlike the WDA, WTI was established as an organisation within the Welsh Assembly Government itself with the department of Economic Development and Transport, rather than as an agency (Salvador and Harding 2005).

Education and Learning Wales (ELWa) and the Department for Education, Lifelong Learning and Skills

Education and Learning Wales (ELWa) was established in April 2001 as a WAG public body responsible for the planning and promotion of further education, work based learning, adult and continuing education, and school sixth forms but excluding higher education, which is the responsibility of HEFCW (see below) (Salvador and Harding 2005). ELWa was initially responsible for the Knowledge Exploitation Fund (KEF), though following difficulties this was handed over to the WDA. At the same time as the WDA was absorbed into WAG, ELWa was taken into the Department for Education, Lifelong Learning and Skills.

Higher Education Funding Council for Wales (HEFCW)

The Higher Education Funding Council for Wales (HEFCW) fulfils the same role as HEFCE in England, overseeing the core funding for teaching and research within Welsh HEIs. While HEFCW plays an important role in the higher-level skills and research spheres of the Knowledge Economy it also manages the Higher Education Economic Development (HEED) fund. This fund is designed to encourage and assist Welsh HEIs to engage with industry and support economic development. This fund is broadly comparable with the Higher Education Innovation Fund managed by HEFCE, DTI and DfES.

2.4 The Future – Wales' 'Convergence' with the Knowledge Economy?

While much effort has been made to address the economic weaknesses of much of Wales, including through use of European Objective 1 funding, the performance of parts of the Welsh economy remains significantly behind that of Europe as a whole. This is highlighted by the fact that much of Wales still qualifies for the highest level of assistance from the EU, now termed 'Convergence Funding'.

As previously descried in this section WAG outlines its strategy for economic development in *'Wales: A Vibrant Economy'* (WAG 2005b). This strategy builds upon the vision of integrating national and regional policy with the vision of the European Union and the 'Lisbon Agenda' of social and economic regeneration. To achieve this Wales has the support of Convergence Funding worth £1.3bn for the West Wales and Valleys region while other areas of Wales qualify for support worth around £120m from the 'Competitiveness Fund', which was previously called Objectives 2 and 3. Most of the funding available (65%) is set for '*Lisbon related investments*' (WEFO 2006a) and has been earmarked in line with 9 European Regional Development Fund (ERDF) and European Social Fund (ESF) priorities (WEFO 2006a);

ERDF

- *Building the knowledge based economy*
- *Improving business competitiveness*
- *Developing strategic infrastructure*
- *Creating an attractive business environment*
- *Building sustainable communities*

ESF

- *Supplying young people with the skills needed for employment*
- *Increasing employment and tackling economic inactivity*
- *Improving skill levels and improving the adaptability of the workforce*
- *Making the connections – modernising our public services*

These priorities are being used to develop 'Strategic Frameworks' that will be operational strategies rather than financial instruments, which combine various interrelated aspects of each priority. These are currently being developed following consultation and are expected to be agreed by March/July 2007. Each framework will be co-ordinated by the relevant department of WAG and administered by WEFO. The Frameworks are (WEFO 2006b);

ERDF

- *Sustainable Regeneration*
- *Research, technology and innovation*
- *E Solutions*
- *Business Finance*
- *Business Solutions*
- *Sustainable Transport*
- *Climate Change*
- *Environmental Risks – Waste Management*
- *Community Economic Development*

ESF

- *Equipping young People with the skills needed for employment*
- *Tackling economic inactivity*
- *Promoting employment retention*
- *Improving the skills base of the workforce*
- *Workforce development and learning systems Skills for the Knowledge Economy*
- *Gender equality in employment*
- *Making the connections*

A detailed listing of the Priorities and Frameworks is included for reference in Appendix 2.

This section has provided an overview of Wales, its economic history and the current strategies of the Welsh Assembly Government. It has been shown that the Welsh economy reacted to the decline of the heavy industrial base by attracting inward investment in a massive restructuring of the economy. Now that this is facing harsh challenges, effort is being focused on the rapidly expanding sectors of the 'Knowledge Economy' to deliver growth. This is reflected in the vision and strategies of the Welsh Assembly Government, heightening interest in Knowledge Economy initiatives such as Technium. With this in mind the next section examines the 'Knowledge Economy' in more detail, presenting the Global, European, UK and regional perspectives.

3. The Knowledge Economy

The Technium initiative has been created to support the development of a Knowledge Economy in South West Wales. This Chapter provides an overview of the Knowledge Economy with global, national and regional perspectives.

Section 3.1 introduces the concept of knowledge and its role in the Knowledge Economy, together with a 'three pillar' model of the Knowledge Economy consisting of: Human Capital, Innovation and Infrastructure. This model is then used in subsequent sections to discuss the Knowledge Economy at the Global, European, UK and Regional levels.

3.1 Introduction

Economies have always been built upon knowledge (EU 1997), though it is only recently that knowledge has become the driving force behind regional, national and global economies. Developed nations such as the UK have seen their economies become increasingly dependent upon knowledge sectors, particularly over recent years.

While much discussion has been made of the rise of the US Knowledge Economy during the 1990s (Stern and Porter 1999), the development of the Knowledge Economy has taken place throughout the world over a more significant timescale. This is shown in Fig.3.1 where the increase in high-technology exports from all OECD nations has taken place since the end of the 1970s (OECD 1996).

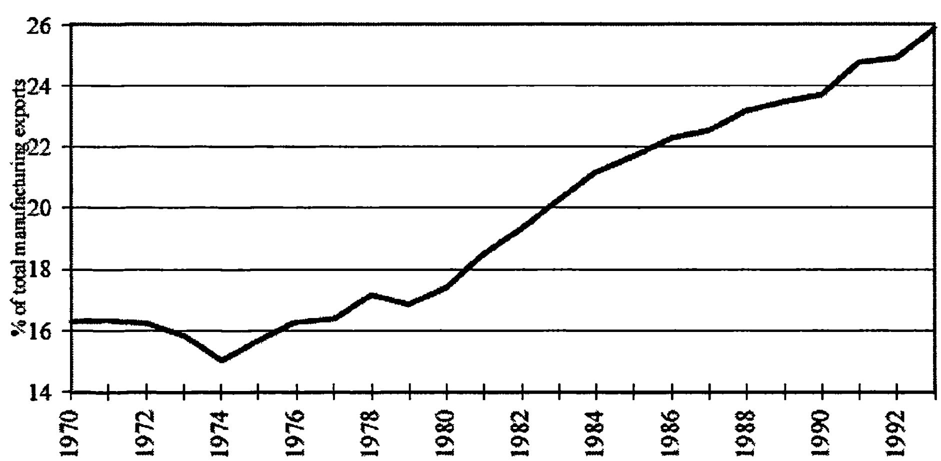


Fig.3.1 Total OECD high-technology exports as a percentage of total manufacturing exports (OECD 1996)

The behaviour of economies has traditionally been studied in relation to the availability and application of production factors of labour, land, capital and natural resources. Economic growth has come from improvements in productivity of these factors, improved labour productivity (e.g. improved skills or longer hours), better use of land (e.g. larger farms), restructuring of industries (e.g. vertical integration) and technological change (e.g. the steam engine) or a combination thereof (Samuelson 1964). However, recent years have seen the emerging dominance of another production factor – knowledge. This also changes the way in which resources are considered for the most important ones are now *created*, rather than *inherited* (Porter 1990) This relates to creating competitive advantage at both the individual firm (Porter 1985) and national levels (Porter 1990). This is captured in the following observation by the World Bank;

"*For countries in the vanguard of the world economy, the balance between knowledge and resources has shifted so far towards the former that knowledge has become perhaps the most important factor determining the standard of living*"

(World Bank 1998)

This chapter examines the concept of the knowledge economy at the global, European, national and regional (Wales and South West Wales) levels.

3.1.1 Knowledge

In consideration of the Knowledge Economy it is useful to consider the core concept: knowledge itself. Traditional economic factors can be (relatively) easily defined and quantified. For example capital can be counted in pounds or dollars, land - in acres or hectares, labour (considered as a physical resource) – number of men (and women) and natural resources in volumes of reserves. There are of course other issues to consider regarding factors, such as quality (e.g. whether land is fertile or located in a useful position such as on a major river or coast, and purity of mineral resources).

However, each of the traditional resources is finite and subject to '*scarcity*' whereby choices have to be made as to how they are to be applied (Samuelson 1964). Knowledge on the other hand is different in that it can be duplicated and disseminated. This means that value can often be exploited from the same instance of the resource several times. Doring and Shnellenbach (2006) provide a interesting study that investigates how this occurs, allowing growth that runs contrary to the traditional neoclassical economics suggestion that growth would only occur in step with the 'stock' of new knowledge.

Furthermore, when knowledge is mixed with other knowledge further opportunities can be realised. This phenomenon is discussed in the context of '*Knowledge Spillovers*' later in this section.

Knowledge is also regarded as a public good and therefore monopolisation of its use is both difficult in terms of practicality and acceptability (World Bank 1999), as Thomas Jefferson recognised;

"*He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me*"

However, Jefferson's fellow countryman, Thomas Edison was later to provide a prime example of how the use of such 'light' could be restricted to its creators benefit. In US patent application No.223,898 the knowledge underpinning the incandescent electric lamp was protected (US Nat Arch 2007).

Knowledge Types

Knowledge exists in various forms which make it complex and therefore difficult to use in economic analysis. The OECD report '*The Knowledge-Based Economy*' (OECD 1996) describes types as including '*Know-what*', referring to facts, '*Know-why*', relating to knowledge such as scientific principles and laws, '*Know-how*' for knowledge such as skill in using a machine or judging a market and '*Know-who*', in recognition of relationships and access to further knowledge (OECD 1996).

However, a useful common dichotomy for knowledge types is into '*codified*' and '*tacit*' types. (Lundvall and Johnson 1994). Codified knowledge is that which is recorded onto some form of media and which can be transferred to others for their use. Tacit knowledge exists within people and is regarded as requiring 'face to face' interaction between supplier and recipient for its transferral (Boddy 2005). A useful illustration of these knowledge types is provided by the World Bank (World Bank 1999); blueprints of a system are an example of codified knowledge, while the experience of an engineer to find the route of a malfunction demonstrates the importance of tacit knowledge. Information, knowledge and its typologies are studied in detail in the work of Lundvall who provides a useful explanation of how tacit knowledge arises through;

"*...learning gives rise to know-how, skills and competencies which are often tacit rather than explicit and which cannot easily be transmitted through telecommunications networks.*"

(Lundvall 1998)

A real-life example of the criticality of tacit knowledge was provided by the espionage activities of the former USSR. Despite the success of the Russian secret service in acquiring the plans to the Anglo-French Concorde, their engineers were unable to completely emulate the performance of the aircraft as they lacked the tacit knowledge of the engineers and technicians who designed and built the original aircraft (Wright 1987).

Tacit knowledge itself comprises various elements – namely information, skills, judgement and wisdom (Gorman 2002). These elements can be developed in an individual over decades from unique experiences, including from previous employment (Lawson and Lorenz 1999). Lawson and Lorenz also describe a form of tacit knowledge arising from 'shared learning' within an organisation.

By its very nature, tacit knowledge is more difficult to duplicate and is therefore central in holding competitive advantage (Coates and Warwick 1999). Its importance has increased significantly with the advent of ICT. As codified knowledge can be disseminated at ever-increasing speeds its exclusivity is easily lost beyond a region. Meanwhile the tacit knowledge, which does not so easily diffuse, can provide competitive advantage to those who have access to it; i.e. those nearby. The idea is captured by Asheim and Isaken (2002) in terms of '*Local 'Sticky'* and *'Global Ubiquitous'*. This is an underlying principle that supports *knowledge spillovers* and the development of *clusters*.

3.1.2 The Knowledge Economy / Knowledge-based economy

The term knowledge-based economy stems from *'the fuller recognition of the role of knowledge and technology in economic growth'* (OECD 1996). The role of knowledge in the economy is embraced in a wide set of concepts including the '*knowledge-driven economy*', '*knowledge-based society*', '*the new economy*', the '*weightless economy*' and the '*learning economy*' (Boddy 2005). Although each of these concepts has been developed by authors examining different perspectives of economics they may be treated as synonymous.

Recent years have seen the greater recognition and discussion of the importance of knowledge due to reasons including disruptive technological advance and globalisation. The drivers of this new 'Knowledge Economy' have been summarised as; (DTI 1999).

- *Revolutionary changes in information and communications technology (ICT)*
- *More rapid scientific and technological advance*
- *Competition becoming more global*
- *Changes in Income, Tastes and Lifestyle*

These drivers have combined to make the Knowledge the main factors in economic growth. Expansion in knowledge sectors is outpacing others to such an extent that more than 50% of the GDP of OECD countries is now knowledge-based (OECD 1996). This is highlighted by the United States, where even in the early part of the 20th Century, 85% economic growth was driven by technological advance (Quah 1999). Further weight is given to this by the changes in employment seen over recent years. Within the EU for example, employment growth in knowledge-based industries has been far stronger than the rest of the economy. This can be seen in the figures from EUROSTAT cited by the Work Foundation shown in Table: 3.1 below;

Change in Employment	**Knowledge-based industries**	**Other industries**
Spain	+ 74.6%	+ 42.4%
Ireland	+ 70.7%	+ 42.9%
Netherlands	+ 29.9%	+ 12.3%
Finland	+ 29.6%	+ 13.5%
Germany	+17.1%	- 8.6%
UK	+ 16.7%	+ 1.0%
France	+ 16.3%	+ 7.3%
Denmark	+ 11.6%	- 0.2%
Sweden	+ 12.8%	+ 2.0%
EU-15	+ 23.9%	+ 5.7%

Table: 3.1 Change in employment in knowledge-based industries in selected EU member states 1995-2005, Work Foundation (2006)

In Table: 3.1 it can be clearly seen that many of the countries experiencing the greatest growth in knowledge-based industries are those developing from the weakest bases (c.f. Table: 3.6 section 3.2.2, p.55). These figures are projected against a period of economic change that saw recession in much of the Eurozone during the early years of the 21st century. This is apparent in the 'other industries' statistic in figure for Germany, which was particularly hard hit during this period.

Defining a Knowledge Economy

The role of knowledge in the Knowledge Economy is described in the definitions of the Knowledge Economy provided by the OECD and the UK DTI:

"*...economies which are directly based on the production, distribution and use of knowledge and information*"

(OECD 1996)

"*...one in which the generation and exploitation of knowledge has come to play the predominant part in the creation of wealth*"

(DTI 2004)

While the above is useful in defining and understanding the origins of the Knowledge Economy, how can it be determined whether an economy is knowledge-based?

Methods such as the World Bank Knowledge Assessment Methodology (KAM) exist for benchmarking performance of countries in the transition to a knowledge-based economy. This builds upon the World Bank 'Pillar Model' of the Knowledge Economy, which describes the key supports of such an economy as being (World Bank 1998):

Human Capital: Educated and Skilled Workers

People; their knowledge, talents, ideas and graft form the fundamental pillar of the Knowledge Economy. Developing a successful regional Knowledge Economy depends upon creating and nurturing the skills, aspirations and motivations of the people therein and attracting talent from outside.

Innovation: An effective innovation system

Regional innovation systems have been shown to be the motors of the Knowledge Economy (UNIEDO 2003). A region's ability to develop new products and services and improve upon the manner it produces existing ones is key in determining its economic fortune. Along with companies these systems include interrelated actors including universities, research centres, knowledge services etc.

Infrastructure: A modern and adequate information infrastructure

To facilitate innovation and create clusters of growing knowledge-based businesses an infrastructure is required for its support. Infrastructure not only encompasses physical entities such as development facilities, offices and ICT systems. 'Soft' infrastructure is equally critical. Important examples include not only enterprise and specialist support such as legal services but also knowledge networks of individuals and organisations that disseminate and exploit knowledge and opportunities.

Economic and Institutional Regime:

The economic environment of a nation or region plays an important part in the growth of the Knowledge Economy. Factors such as taxation, strength of Intellectual Property Rights, export controls/tariffs etc. are examples of this economic and institutional regime. Many of these aspects of the Knowledge Economy are managed at the UK or EU level. They therefore fall outside the devolved powers of the National Assembly for Wales and regional actors. It is however, important to understand how they affect the regional Knowledge Economy in order to maximise potential growth and opportunities.

Using these pillars the KAM system tracks variety of including: literacy of population; availability of ICT; levels of entrepreneurship and innovation; proportion of population with higher level skills etc. As these indices are easily collated and comparable between nations it makes benchmarking straightforward. However, as the methodology was developed to assist developing countries, many of the indices used are less relevant to developed nations.

Threshold of a Knowledge Economy

While the concept of the Knowledge Economy is clear, the challenge remains in determining the extent to which an economy is knowledge intensive (Shapira et al., 2005). A practical approach toward defining whether an economy is 'knowledge-based' is to determine whether it exceeds a threshold of knowledge intensiveness. Using their sectoral definition of the Knowledge Economy the OECD (OECD 1996) provides such an approach, defining a knowledge-based economy as being;

"*..an economy in which more than 40% of employees are employed in high technology manufacturing and knowledge-intensive industries*"

(OECD 1996)

Cooke and De Laurentis (2003) have used this approach to study the role of the Knowledge Economy in various European regions demonstrating significantly varying knowledge intensiveness across the EU.

This approach of tracking knowledge intensive sectors provides a useful metric in that it makes use of official statistics that are consistent across national and regional boundaries. However, a sectoral approach is limiting in that the Knowledge Economy is relevant to all industries, not only those included in the definitions provided by EUROSTAT and the OECD (1996). This applies in particular to those sectors not related to science, engineering and technology (SET).

Non-SET and Service sectors

Knowledge-economy activities are often noticeable in the domains of Science, Engineering and Technology, particularly those which manufacture some patented product, though it is important to give consideration to the wider economy, in particular the service sector. Many of these, such as finance and telecommunications are captured in the OECD '*knowledge-intensive industries*' definition (Coates and Warwick 1999). Growth in services led to almost all of the new jobs created in the EU in the period 1997-2002 and account for 70% of EU added value (EU 2005).

The importance of all sectors to the Knowledge Economy is emphasised by Michael Porter in '*The New Challenge to America's Prosperity: Findings from the Innovation Index*', (Porter and Stern 1999) where he outlines that there are no 'low tech' industries, only companies that fail to embrace new ideas and methods into their products. Porter and Stern also emphasise innovation in the context of '*discerning and meeting the needs of customers*', rather than being a domain restricted to science and engineering, arguing that improvements in marketing, distribution and service can be as important as those generated in laboratories relating to new products and processes.

The role of the service sector in the Knowledge Economy and its economic impact is emphasised by the growth in knowledge services over the past decade. This is shown below in Table: 3.2, cited from the Work Foundation report for the 2007 EU Spring Council (Work Foundation 2006).

	Change (jobs)	Change %
Business and Communications	+ 5,090,000	+ 54.5%
High tech services	+ 1,581,000	+ 37.1%
Health and Education	+6,838,000	+ 26.7%
Financial Services	+ 129,000	+ 2.5%
Total Knowledge Services	+ 13,637,000	+ 30.7%

Table: 3.2 Growth in Knowledge Services in EU15 1995-2005
Source: EUROSTAT, cited from Work Foundation 2006

The importance of non-SET sectors is supported by historical observations. Peter Drucker in his book '*Innovation and Entrepreneurship*' (Drucker 1985) describes how the economic growth of the US in the second half of the 20^{th} Century saw only one eighth of new jobs created in high technology. In fact technological effects such as automation often had negative effects on job creation. However, while robots appearing in factories may be an obvious example of how technology has affected manufacturing industries it should be remembered that something similar has also happened in the service sector. Telephone and on-line banking, e-commerce etc. are all examples of how growth in services has been accompanied by rationalisation and labour saving innovation (Hauknes 1999).

3.1.3 Knowledge Spillovers

Knowledge Spillovers allow knowledge to be reused providing increased productivity through greater leverage of the investment made into its creation or acquisition (OECD 1996). Whereas other resources such as capital or fuel can only be exploited once, knowledge can be used to provide many and separate returns. For example, research for materials to make stronger car components may also allow improvements in aerospace components.

Spillovers can occur between organisations of any type and can be either intra- or inter-industry (Cantwell and Piscitello 2005). They can occur between organisations of any nature, and also through intermediaries (Lawson and Lorenz 1999). Another interesting factor in knowledge spillovers is that they can be voluntary or involuntary (EU 2003). The spillover of knowledge within regions is an important driver of cluster theory, which is described later in this section, though the spatial spilling of knowledge is not restricted to regions, particularly thanks to modern communications systems and the increasing mobility of workers. Research by Luintel and Khan (2004) for example demonstrates this cluster development role, together with the potential negative effects of spillovers. Their work describes how research and development spillovers from the US provide greater assistance to competitors than that which they receive in return.

Both public and private investments in basic research can have significant spill-over effects beyond their initial objectives (Porter and Stern 1999). Public sources of knowledge are of particular importance as they are more likely to spill-over, as the dissemination of knowledge is typically part of the mission of the public research institution (Doring and Shnellenbach 2006).

The knowledge involved can be technical or non-technical in nature and spill from one industry to another. Tacit knowledge spillovers tend to be localised in nature (Boddy 2005). As ICT makes dissemination of codified information fast and inexpensive, face to face interactions and interpersonal relationships have come to have a comparative advantage in facilitating tacit knowledge flows (Porter 1990). The effects of these spillovers have been shown to be important drivers of cluster development.

However, as described by Doring and Shnellenbach (2006), knowledge spillovers do not only give access to 'exclusive' knowledge available from a specific source, but also provide easier or cheaper access to other, often widely available knowledge.

The effect of knowledge spillovers not only figures as a benefit to existing businesses within a locality, but also as a factor influencing the decisions of multinational firms as to where they locate R&D operations (Cantwell and Piscitello 2005).

3.1.4 Clusters in the Knowledge-Based Economy

Overview

All firms in a region have a certain level of interdependence, in what are ultimately aggregated to represent regional, national and international economies. However, where geographically concentrated groups of interrelated businesses and other organisations participating in a certain field exist, they are regarded as a cluster (EU 2003). While the term 'cluster' has been increasingly used over recent years, the concept has been apparent for centuries and acknowledged for some time, though perhaps subject to different terminology. Rocha (2005) for example charts how academics have studied the phenomenon since the 'Industrial Districts' described by Marshall in the 1890s, all the way through to Porter (1990) at the end of the last millennium. Rocha's work cites early examples of silk traders in China, along with the coming together of suppliers and manufacturers during the industrial revolution, together with their contemporary equivalents, such as the software companies of India or the call centres of Sydney.

These groupings of companies suggest that much of the competitive advantage enjoyed by their members lies outside the firm (Porter 2000), such that the '*the whole is greater than the sum of the parts*'. Porter describes how 'clustering' can help the productivity of both firms and regions in a number of ways:

- *increasing the productivity of constituent firms or industries*
- *increasing the capacity of cluster participants for innovation and productivity growth*
- *stimulating new business formation that supports innovation and expands the cluster*

Elsewhere Porter and Stern (1999) provide a formal definition of the concept (which is also used by the DTI (2001);

'*Clusters are geographically proximate groups of interconnected companies, industries, and associated institutions in a particular field, linked by commonalities and complementarities.*

As the definition suggests a cluster does not include solely competing firms, but is a much broader phenomenon which "*extend*(s) *downstream to channels or customers and laterally to manufacturers of complementary product* (and services) *or companies related by skills, technologies or common inputs*" (Porter 2000). This encompasses the roles of other stakeholders within clusters including universities, trade associations and government.

Porter and Stern (1998) also point out that not all actors within a cluster are necessarily aligned with a particular industry, though rather they come together to support each other's innovative activity. However, when considering a cluster it should be done with regard to the sector under investigation as aggregation to the level of industry or broad groupings such as 'manufacturing' or 'high-technology' lose the meaning of the connections and interrelationships.

Clusters exist in all manner of industries, though are of particular interest in knowledge-driven sectors because of the importance of localised skills and tacit knowledge spillovers. Clusters differ from networks in that they do not rely on any formal or informal organisation of actors such as chambers of commerce, industrial fora etc. (EU 2003). Furthermore, clusters are not necessarily dominated by large companies: an EC study (EU 2003) shows that they typically involve a mix of small and large firms, as shown in Fig. 3.2[5].

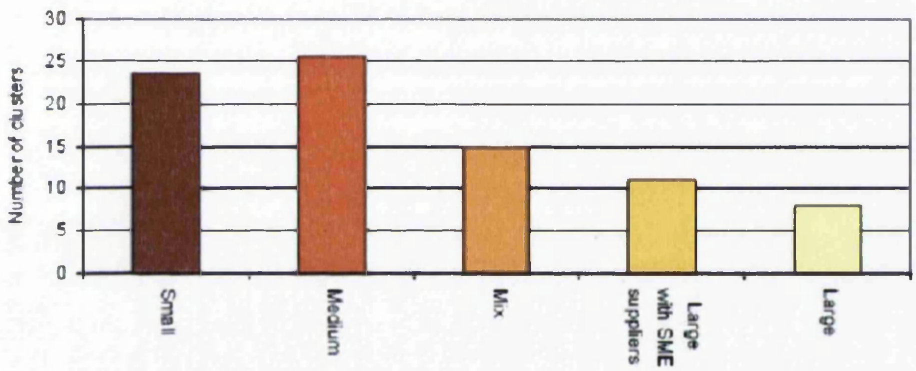


Fig. 3.2 Dominating firm size of clusters included in European Commission study (EU 2003)

Clusters historically often developed around a natural resource, such as mineral deposits or a natural harbour, or a large market, such as towns or cities. This last influence is still reflected in the European Commission study of European clusters which shows most exist in urban settings (EU 2003);

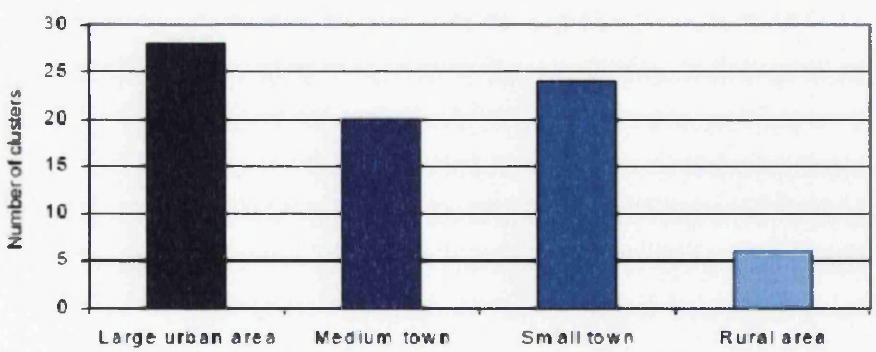


Fig. 3.3 Geographic location of clusters included in European Commission study (EU 2003)

[5] The role of these different sized actors is specifically addressed as part of this study

Many clusters have developed around the availability of knowledge in the region and this is evermore important in the modern Knowledge Economy sectors. This leads to co-location of firms, the spin-off and start-up of new related firms and the development of other businesses to support their activities, and the growth of a cluster. The nature of such firms is not just competitive and often occurs with overlap between sectors (e.g. venture capitalists, patent attorneys, recruitment agencies, accountancy firms etc.). The interrelationships that give rise to this are presented in Porter's 'Diamond' Model shown in Fig. 3.4 below.

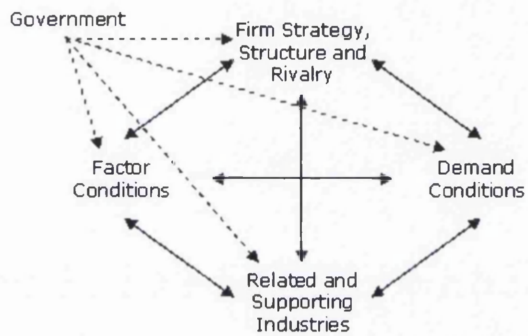


Fig. 3.4 Porter's 'Diamond' Model for Competitive Advantage of Nations (Porter 1990)

Clusters of businesses related to a specific sector not only draw upon the common innovation infrastructure (or *innovation system* as discussed later), but also add to it, creating a self-reinforcing virtuous circle (Porter and Stern 1999). This effect is also demonstrated by the work of Varga (2000), who notes, however, that a critical mass of agglomeration within the region is needed for this to occur.

The study conducted by the European Commission also investigated the interaction and types of networking between businesses in the clusters examined. As shown in Fig.3.5 most of the clusters investigated had extensive informal networking and collaborative R&D activity;

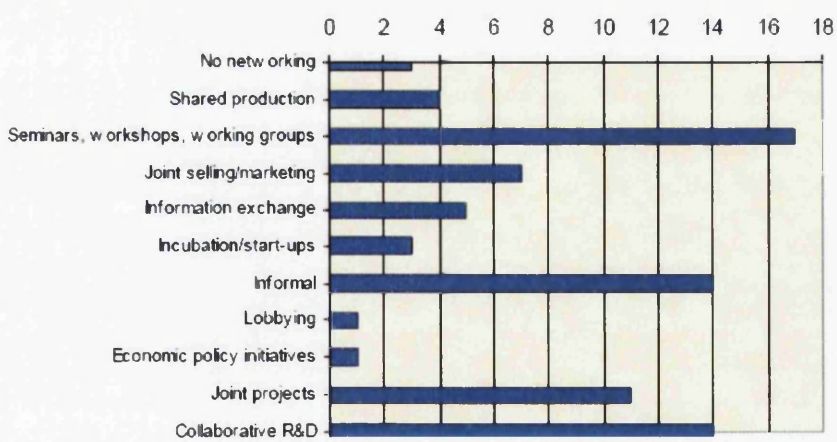


Fig. 3.5 Networking between firms in clusters: European Commission study (EU 2003)

The virtuous circle can lead to growth that is then compounded by the establishment of reputation, further attracting skills, investment and opportunities to the region. Examples of this include 'Silicon Valley' (Bresnahan et al. 2001) and 'Route 128' (Dorfman 1983), along with Silicon Glen (Turok 1993) and Cambridge Biotechnology clusters in the UK (Keeble and Tomlinson 1999).

As described earlier the effects of clusters do not solely relate to existing firms therein, but also to the formation of new enterprise. The availability of new opportunities within a cluster helps promote entrepreneurship and the presence of support organisations, potential customers and suppliers acts to facilitate innovation and entrepreneurship (Rocha 2005). The presence of local networks can also help decrease cost and uncertainty in the development of start-ups, aided by flow of knowledge (Alkmeida and Kogut 1997).

Knowledge and Innovation

Clusters also represent a foundation for the formation of formal and informal knowledge distribution networks that support innovation (OECD 1996), which ties in with the concept of knowledge spillovers discussed earlier. The information and knowledge exchange within clusters is the key driver in their development in what Keeble and Wilkinson term an '*innovative milieu*' (Keeble and Tomlinson 1999) as part of '*regional collective learning*'. This concept describes the development of a collective regional knowledge base caused through interactions such as networking, research collaborations and the movement of personnel between companies and other organisations.

Proximity

Proximity is a key component in successful clusters (OECD 1996, Porter 2000), particularly in regard to facilitating knowledge-spillovers (EU 2003), described as;

"*The proximity of customers, competitors, suppliers, universities and research institutions provided impetus (for) the creation and exchange of information and increases opportunities for innovation.*"

(EU 2003)

Maskell and Malmberg (1999) outline how the competitiveness of a firm, particularly in the long-term, depends upon its ability to continuously upgrade its knowledge base. To achieve this it must find knowledge sources that provide competitive advantage. As tacit knowledge is the least transferable it requires that businesses place themselves close to its source. Additionally, cost is a factor in developing and maintaining a company's knowledge base, making proximity to knowledge sources a cost-effective way of closer and more frequent personal contacts.

However, while proximity to sources of knowledge and other linkages are important elements of clusters, it must not be forgotten that high-technology companies generally exist in national and international networks, serving global markets (Keeble and Tomlinson 1999).

Clusters on Demand?

Clusters are generally built up spontaneously (EU 2003). However, the question remains as to whether it is possible to develop them in cities and regions and how it could be achieved. The conclusion put forward by governmental organisations (EU 2003), academics (Cooke 2002, Porter 2000) and other bodies is that it is possible, subject to the availability of key components including leadership and vision (Porter 1990, Cooke 2002).

This is in keeping with the model proposed by Porter (1990, 2000), where government can affect aspects including factor conditions, firm strategy, and rivalry and demand conditions. Examples of each of these include provision of training or new knowledge (e.g. funding training schemes or funding academic research), competition policy (regulation/deregulation of industries) and changing consumer behaviour (e.g. environmental legislation), as shown in Fig. 3.6 (Porter 2000). It is also suggested that because of the importance of proximity regional administrations are best placed to assist cluster development (EU 2003).

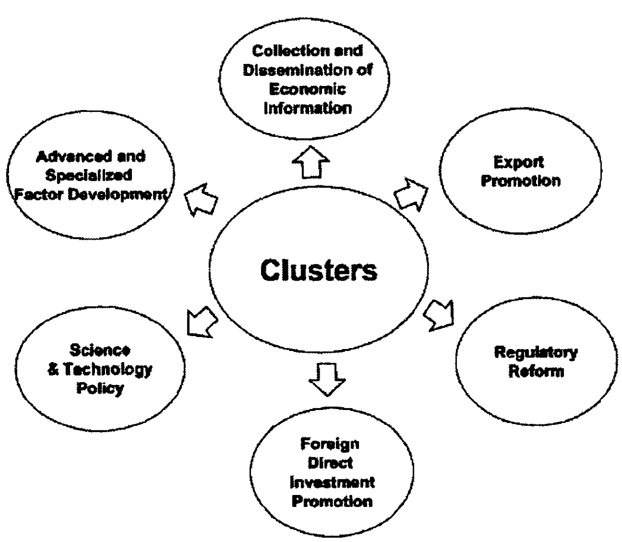


Fig. 3.6 Aspects of Economic Policy in Cluster Development (Porter 2000)

UK and Wales

On a global scale the DTI report 'UK Competitiveness: Moving to the Next Stage', (Porter and Ketels 2003), presents the UK as a whole as figuring in a number of significant clusters including services, defence, telecommunications, health care, entertainment and many others. Further sectors such as biotechnology and motor sport are also noted to be of particular significance.

Wales and our Wales Spatial Plan region are already acknowledged as supporting a number of sector clusters including electronics, biotechnology, automotive and aerospace. These have been identified in the DTI study of UK clusters (DTI 2001). Each of these represents a significant amount of employment and number of businesses.

Cluster	Employment
Electronics	22,000
Automotive	12,000
Aerospace	5,650
Biotechnology	2,147

Table 3.3 Employment in selected Welsh clusters (DTI 2001)

While not all of the employment may refer to higher skilled employment or 'knowledge workers' the sectors involved fall within sectoral definitions of the knowledge economy (OECD 1996) and present the importance of the knowledge economy employment within the region.

An observation in the DTI assessment of clusters (DTI 2001) in Wales is that while there exists significant specialisation with a number of clusters, they are generally and often weakly embedded and dependent upon foreign owners and markets or industries across the border in England. This reflects the concerns, relating to FDI discussed in Chapter 2 (Phelps et al. 2003), regarding the 'embededness' of businesses in the region and the focus given to developing indigenous enterprise within sectors and clusters (Cooke and Clifton 2005).

3.1.5 Knowledge Economy - Global, European and UK

Global

As described earlier, the emergence of the knowledge-based economy around the world has been widely acknowledged at an international level, (OECD 1996, Work Foundation 2006), and also increasingly so at national (DTI 2003, Shapira et al. 2005) and regional levels. This has led to many countries large and small developing strategies to harness the opportunities of the Knowledge Economy, including nations as diverse as the US, UK (DTI 2004), New Zealand, Malaysia and Scotland (Scot Exec 2001).

Knowledge creation is a key driver of the Knowledge Economy and the United States is the world leader in this regard investing the most into the creation of knowledge; some $285bn annually. This compares with other leading nations as shown in Table. 3.4 (OECD 2005);

Country	R&D Investment	As % of OECD expenditure	As % of National GDP
United States	$285bn	42	2.6
EU	$211bn	31	2.0
Japan	$114bn	17	3.2

Table: 3.4 R&D Expenditure by leading nations (OECD 2005)

EU and UK

Developing the world's strongest Knowledge-based economy has become a key goal for the European Union as launched at the Lisbon 2000 Council;

"*...to become the most dynamic and competitive knowledge based economy in the world*"

(Lisbon 2000 EU Council Strategy)

At a European level the disparities in economic performance between regions, even within countries, are highlighted by recent figures compiled by the European Commission (EUROSTAT 2004) and shown in Fig.3.7. The United Kingdom provides the most striking example of this with Inner London generating GDP per capita at 288% of the EU average while at the other end of UK performance are the Isles of Scilly registering 65% (Wales Objective One region – 73%).

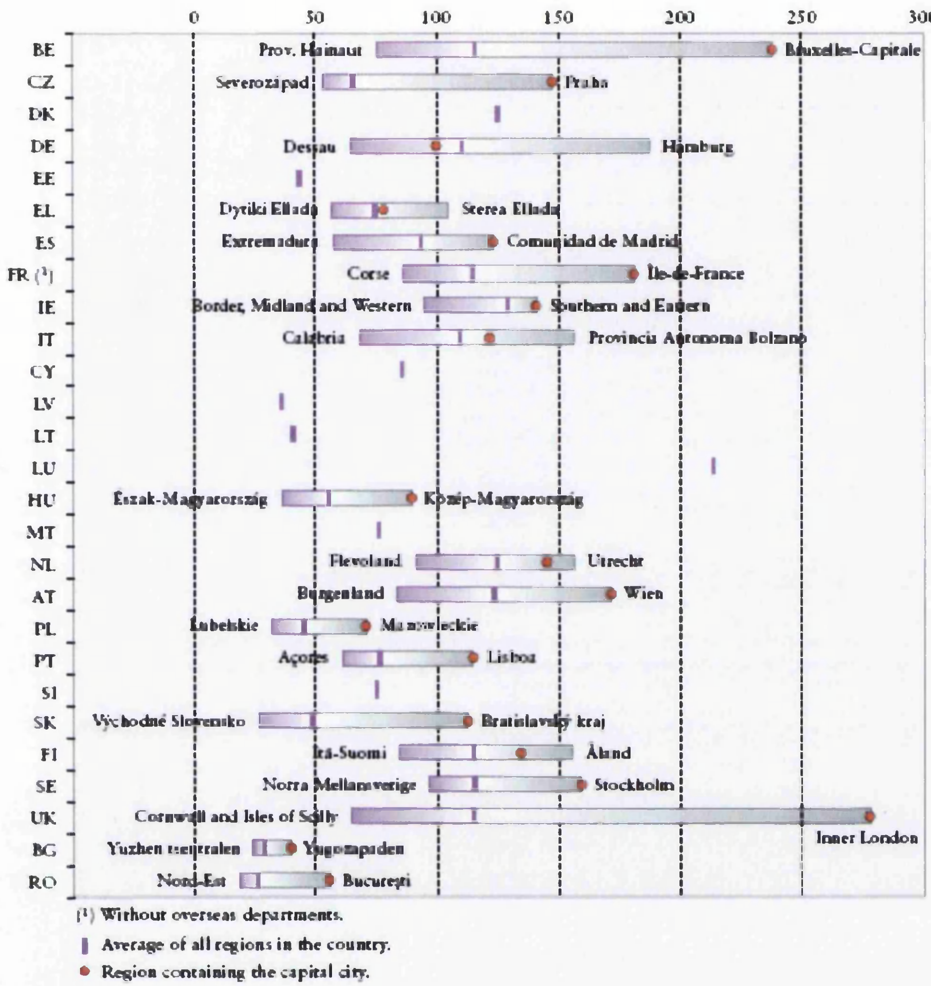


Fig: 3.7 GDP per capita 2001, NUTS 2 level in % of EU-25 average (EU-25 = 100)

The leading regions are typically those including the capital city and this performance aligns with the intensity of knowledge-based activity as has been shown in Cooke and Clifton (2005). However, this measure serves to highlight one of the limitations of simple GDP measures. As 'output' location is recorded rather than 'income' region the apparent prosperity of regions can be misleading. For example, relatively few people live in Central London, though a huge amount of GDP is generated. Much of the wealth created in the capital flows out in pay packets to be spent in the commuter-belt. Wales experiences the same phenomenon, with workers flowing into the capital, many from the relatively poor Valleys, to create GDP that registers as an output of Cardiff.

The need to invest in the Knowledge Economy is at the heart of the European Union's Lisbon Strategy. Investment in human capital and development of innovation is recognised as the key mechanism for realising the strategic objectives. The European Commission's accompanying

'Community Lisbon Programme' proposes development of policy measures under the themes of (EU 2005);

- *Knowledge and innovation for growth*
- *Making Europe a more attractive place to invest and work*
- *Creating more and better jobs*

Much of the Community level action focuses on issues such as reform of state aid, removal of obstacles to physical, labour and academic mobility and completion of an agreement in the ongoing World Trade Organisation negotiations. However, as described in Chapter 2, this follows through down to the national and regional levels, including strategy for Structural Funds interventions.

Considering the intentions of the European Union, how does it currently perform in terms of the knowledge-based economy? Statistics compiled by EUROSTAT show that over 40% of EU employment is in knowledge-based industries with about half of this in manufacturing and market services (i.e. not Health or Education), as shown in Table 3.5;

Sector	% of total employment
Tech based manufacturing	**6.9%**
- High-tech manufacturing	1.1%
- Medium tech manufacturing	5.8%
Market Services	**15.3%**
- High tech services	3.5%
- Financial services	3.2%
- Business / Communications	8.6%
Health, Education, Cultural	**19.4%**
Total	**41.5%**

Table: 3.5 EU Knowledge Based Employment – 2005, WORK FOUNDATION (2006)

The importance of the Knowledge Economy is continually growing in the UK. Current trends would see manufacturing and agriculture account for only 15% of UK output by the end of the decade as the service sector continues to grow (Leadbeater 1999). These trends are reflected in the growth of employment in knowledge-based industries since the mid-80s shown in Fig.3.8.

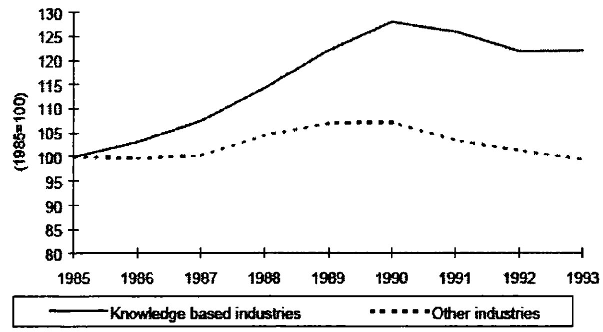


Fig. 3.8 UK Employment in Knowledge based industries, from Coates and Warwick (1999)

However, this overall growth of the Knowledge Economy sits above a wide variance in performance amongst UK regions that is acknowledged by both Government (Edmonds 2000, DTI 2001) and academic observers (Hughes 1999, Cooke 2002, Clement 2004, K Group 2006).

3.1.6 Knowledge Economy - Welsh and Regional Context

Chapter 2 described the restructuring over recent years of the Welsh economy in the face of global challenges that have squeezed traditional sectors, in particular manufacturing. It also discussed how the recently formed Welsh Assembly Government is trying to support the development of the knowledge-based economy. This ambition, reflecting the pillars of the knowledge economy is captured in the Wales Spatial Plan (WAG 2004c);

"*We need an innovative, high value economy for Wales which utilises and develops the skills and knowledge of our people: an economy which both creates wealth and allows that prosperity to be spread throughout Wales: an economy which adds to the quality of people's lives as well as their living and working environments.*"

Wales Spatial Plan (WAG 2004c)

Great differences in prosperity can be noted within the regions of Wales (Morgan 2001). This is demonstrated by Fig. 3.9 presenting the disparity between East Wales, and West Wales and the Valleys (K GROUP 2006).

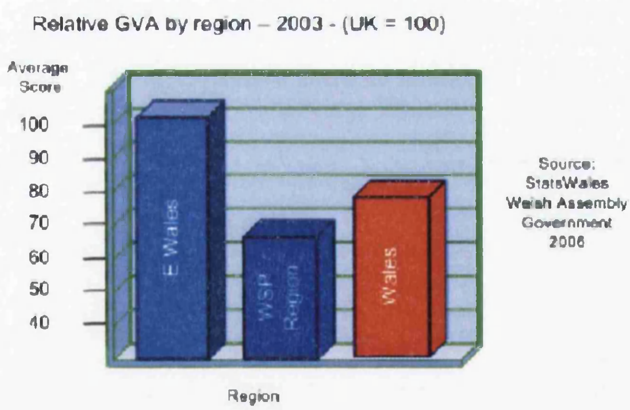


Fig. 3.9 GVA by South Wales region compared to UK average – 2003
from Knowledge Economy Theme: Interim Report:
Wales Spatial Plan, Swansea Bay, Waterfront and Western Valleys

Using a definition developed from the OECD sectoral description of the knowledge economy (OECD 1996), Cooke and De Laurentis (2003) present the regions of West Wales and the Valleys against other key European regions (in Fig.3.10 following):

Region	More than a 40% knowledge economy		Region	Less than a 40% knowledge economy	
Stockholm, Sweden	58.65	(1)	Geldedand, the Netherlands	39.99	(87)
London, UK	57.73	(2)	North East Scotland, UK	38.09	(101)
Helsinki, Finland	51.50	(11)	Northern Ireland, UK	37.31	(107)
Paris, France	50.17	(16)	Sachsen, Germany	35.97	(119)
South West Scotland, UK	47.59	(24)	Highlands and Islands, UK	34.45	(132)
East Scotland, UK	47.05	(30)	Upper Austria	34.28	(133)
East Wales, UK	43.91	(53)	Athens, Greece	33.79	(135)
West Wales and Valleys, UK	42.87	(60)	Calabria, Italy	31.29	(151)
Rhône-Alpes, France	42.22	(67)	Navarre, Spain	32.06	(145)
South and East Ireland	40.18	(86)	Aegean Islands, Greece	12.70	(188)

Fig. 3.10 Selected regions from the Knowledge Economy Index (1998)
Cooke and De Laurentis 2003

This suggests that both 'East Wales' and the 'West Wales and Valleys' regions 'qualify' as regions with a knowledge-based economy, meaning that there is an existing knowledge-economy to be supported and developed.

'West Wales and Valleys' includes the Wales Spatial Plan region of Swansea Bay, Waterfront and Western Valleys, which is developing its own Knowledge Economy strategy as part of the Spatial Planning process. The neighbouring region of 'East Wales' is also developing a strategy for development of the Knowledge Economy using the services of an external commercial consultancy (Local Futures 2006).

The research and strategy development of the South West Wales effort is being driven by the Knowledge Economy Research Group at Swansea University. This work has focused on identifying regional challenges, relating to human capital, innovation and infrastructure, and developing recommendations and actions through use of regional and international experts (K-Group 2006, Davies et al. 2007)[6]. This approach to developing 'regional' knowledge economy strategies has been adopted in the United States, Europe and the UK (Boddy 2005).

[6] The identification of regional challenges in this process forms part of this study of Technium

3.2 Human Capital

3.2.1 Education and Skills

Human Capital is the driving force behind the knowledge economy and it is for this reason that skilled labour is in the highest demand in OECD countries (OECD 1996). It has been demonstrated that investing in Human Capital provides returns to individuals, firms and the economy as a whole (Blundell et al. 1999). During 1996 it was observed that unemployment amongst OECD population with lower secondary education, ran at 10.5%, falling to 3.8% for those with a 'university' education (OECD 1996).

Many of the employers within developed nations that require modest skills levels are already relocating overseas to where labour is cheaper. It is only through upskilling and presenting a comparative skills advantage that developed nations can compete (Porter and Stern 1999) and satisfy the knowledge-based economy's thirst for highly skilled workers. The driving factor behind this increasing higher skills need is technological, as new technologies that improve productivity require greater skill, though fewer individuals (OECD 1996). This has led to countries around the world aiming to improve skills levels amongst their workforce and to command a 'premium' for those who posses them. While higher skills have traditionally attracted higher wages this premium has been increasing since the 1960s (Murphy and Welch 1992). The current extent of this premium is clearly shown in work done by the UK ONS showing the earning differential between individuals with and without degree level education in a range of sectors (as presented in Fig.3.11.) (ONS 2004);

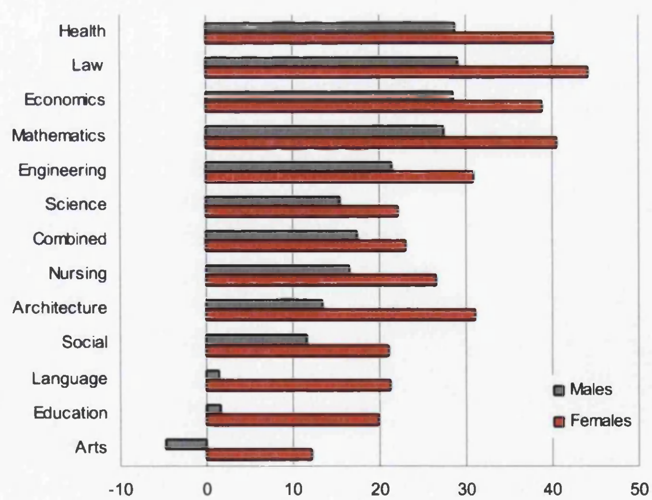


Fig. 3.11 Proportional effect (%) on earnings of a degree level qualification: by sex and degree subject, 1993-2001 (ONS 2004)

This changing of skills requirements in the Knowledge-Based economy is also creating growing need for ongoing skills development. This is reflected in the recommendations of the recent UK HM Treasury Review of Skills (Leitch 2006) to encourage investment in skills, improve skills across all levels and to give greater focus on providing the skills needed by industry.

Developing Human Capital is of particular interest in the context of tackling economic inactivity, which is one of the main challenges facing the Welsh economy. Those without formal qualifications are the most likely to be economically inactive and the increase in economic activity seen over the last 20 years is the most acute amongst this group suggesting the employability of this group is becoming increasingly difficult (WEFO 2004).

3.2.2 HC - Global, European and UK

Global

Despite the key role of Human Capital, recent trends have seen the production of new researchers has recently slowed across developed nations with the weakest growth within universities and public sector research facilities (OECD 1996). This is important, for the stock of such individuals is a key indicator of the ability to create, develop and exploit knowledge.

The challenge of encouraging young people to study science and technology is recognised at international (OECD 1996), national and regional levels (WAG 2006). This also highlights the need to measure skills stocks within nations and regions. The United States for example produces a high number of graduates each year, but only 16% are in Science and Engineering. This compares to 27% in the EU and 26% in Japan (OECD 2005).

EU

In 2005 over 40% of the EU workforce was employed in knowledge-based industries (EUROSTAT definition) with the UK having the third highest proportion (48%) after Sweden (54.3%) and Denmark (49.1%); see Table: 3.6 below (Work Foundation 2006);

	Manufacturing	Services	Total
Sweden	6.5%	47.8%	54.3%
Denmark	6.3%	42.8%	49.1%
United Kingdom	5.6%	42.4%	48.0%
Finland	6.8%	40.5%	47.3%
Netherlands	3.3%	41.9%	45.2%
Germany	10.4%	33.4%	43.8%
France	6.3%	36.3%	42.6%
Ireland	6.0%	33.9%	39.9%
EU-15	6.7%	34.7%	41.4%

Table: 3.6 Employment in Knowledge-Based Industries in selected EU Member States – 2005 (Work Foundation 2006)

From the above it is clear that most of the knowledge-based employment exists within 'services' rather than manufacturing industry. The reason for such high figures across all nations is the inclusion of sectors such as 'Health' and 'Education' both of which are particularly labour intensive. The rather high German entry under Manufacturing is a result of the inclusion of the 'automotive sector' within the definition of knowledge-based industries.

UK

Since the acknowledgement of a 'skills gap' that was harming national competitiveness (Edmonds 2000) the development of Human Capital, particularly higher level skills is central to the UK Government's strategy to support the Knowledge Economy (DfES 2003). This is also reflected in the strategies of the devolved territories (WAG 2003b, Scot Exec 2001). More recently the Leitch (2006) Review of Skills has highlighted the need to address this gap for the UK economy to be competitive in the future.

While the figure for UK SET employment shown in Fig: 3.12 is encouraging (due to particular strength in services), this is an average of widely differing performance by individual regions.

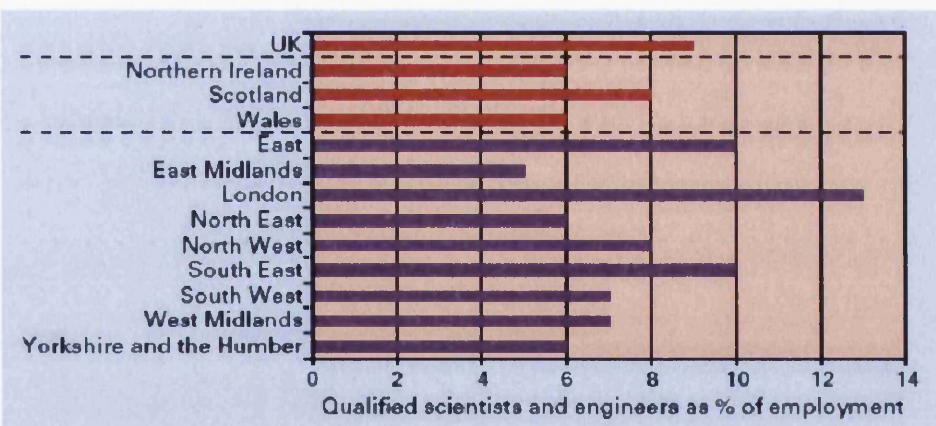


Fig: 3.12 Scientific skills by region, 1998-2000, (DTI 2003)

Fig: 3.13 on the following page shows the distribution of knowledge-based workers including those in SET and services. One point of interest in Fig: 3.13 is the relatively strong performance of regions such as the West Midlands. In this context it is again worth noting that automotive manufacture is regarded as a knowledge-based sector, for Wales comes out more strongly in Fig: 3.13 than Fig: 3.12, while SW England appears weaker.

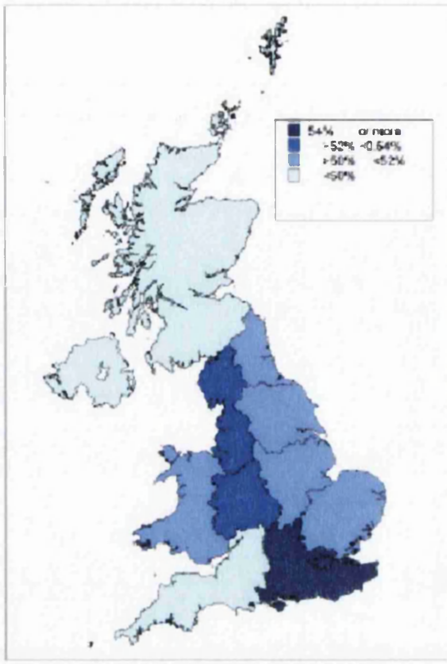


Fig. 3.13 Percentage of employment in knowledge-intensive sectors in the UK, 2000 (DTI 2001)

3.2.3 HC - Welsh and Regional Context

The strategy of the Welsh Assembly Government is not only to create more job opportunities, but also to improve overall skills levels and create *better* jobs (WAG 2005b). However, the nature of this challenge varies across Wales.

The manner in which the structure of the Welsh economy affects productivity is clear when considering skill levels in employment. As shown in the Fig: 3.14 below, Wales as a whole has a greater proportion of low skilled jobs and a smaller proportion of the most skilled types of employment than the UK as a whole. Also apparent is the disparity across the region where the best performing area, Swansea, has a far better mix of employment than Neath, which has a far greater dependence on low skilled employment.

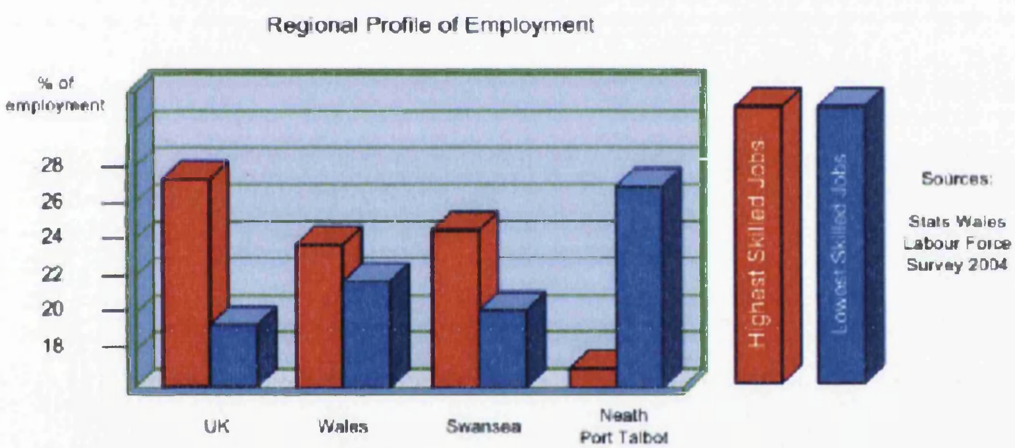


Fig. 3.14 Territorial Breakdown of Employment:
Highest and Lowest Skills Levels (Labour Force Survey 2004)

While the issues described above are challenges for the economy, they are also opportunities. For example, the opportunity to increase productivity through tapping regional pockets of economic inactivity is highlighted in the DTI UK Competitiveness Report (Porter and Ketels 2003) and is a central strand of the WAG strategy for economic development (WAG 2001, WAG 2005c). Furthermore, scope for changing the structure of the regional economy to develop more higher-skilled jobs is a clear avenue to provide improved economic performance, along with social, cultural and environmental benefits.

Basic Skills

In Wales just over one in five working-age adults has no qualifications, though some areas of the country are particularly acutely affected, including Neath Port Talbot in the Swansea Bay, Waterfront and Western Valleys Spatial Plan region. This reflects a severe lack of basic skills within certain parts of the population, leaving many ill-equipped for developing roles within the Knowledge Economy. This challenge is most significant for the 24% of the population who lack the most basic level of literacy and over half of whom lack the most basic numeracy (WAG 2005c). While the aspiration of the Welsh Assembly Government is to provide the population with at least Level 3 skills, it recognises that in order to achieve this goal, focus must also be given to addressing this lower level challenge (WAG 2001).

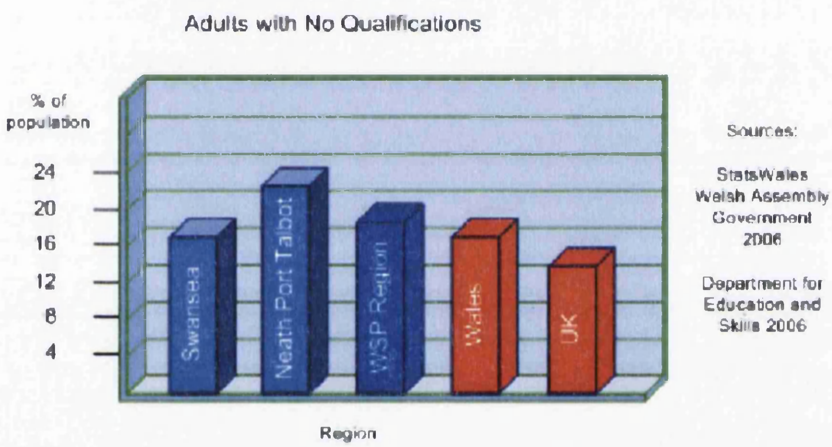


Fig. 3.15 Adults with No Qualifications by Region
StatsWales 2006 and DfES 2006

Basic skills are also critical to higher level skills, facilitating their acquisition and thereby helping open up opportunities for individuals and their employers. Furthermore, choices made at the basic skills and school level can dictate what opportunities are available to an individual for education and career progression. This is reflected by the ambition of the UK Government to encourage more school children to pursue science at GCSE level (DTI 2006).

Higher-level Skills

The geographical spread of higher level skills within Wales varies inversely with increased proportion of unqualified persons in a region (StatsWales 2006). While also having a high proportion of the population lacking basic skills, Neath Port Talbot is burdened by a lack of higher level skills. This phenomenon ties in with the direct relationship between greater educational attainment and higher earnings, and this feeds into the economic performance of the regions in terms of GDP/GVA (per capita). In terms of specific skills, Wales has one of the lowest UK proportions of qualified scientists and engineers[7]. Addressing this issue is one of the objectives of the WAG Science Policy (WAG 2006).

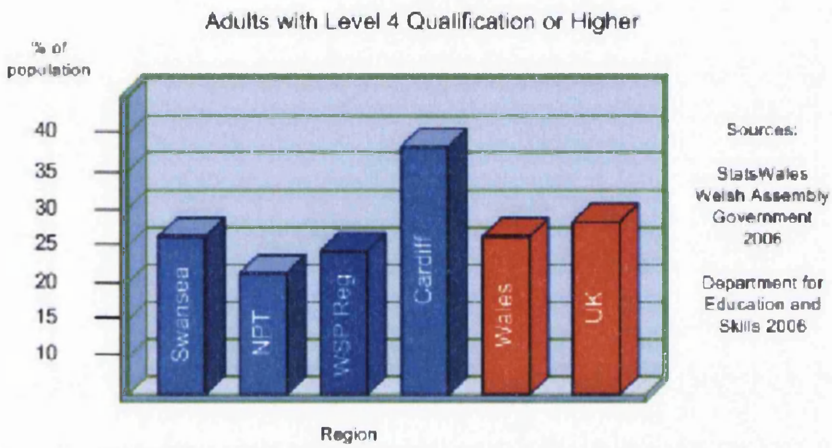


Fig. 3.16 Adults with Higher Level Skills by Local Authority
StatsWales (2006)

[7] Community Innovation survey, 1998-2000

3.3 Innovation

3.3.1 Introduction

"*Most innovations fail*" is the negative start to Henry Chesbrough's much cited work on Open Innovation (Chesbrough 2003). If this is the case, why do companies try to innovate, why do governments encourage them to do so and why do people write books about it? The answer, also offered by Chesbrough, in the very next sentence is, – "*companies that don't innovate die*". This criticality of innovation is echoed through governmental and corporate strategies throughout the world.

Recent years have seen much focus on how innovation can lead to improvements in productivity assisting in economic development (DTI 2003). However, while the term innovation often conjures up images of electronics, test tubes and new products the much wider-reaching nature of the concept has been understood for some time (Schumpeter 1934) to include;

- *The introduction of a new good – one with which consumers are not yet familiar, or the quality of a good*
- *The introduction of a new method of production – which is not necessarily founded upon a new scientific discovery but can be a new way of handling an existing commodity*
- *The opening of a new market*
- *The conquest of a new source of supply – such as raw materials or half-manufactured goods*
- *The carrying out of the new organisation of any industry – such as creation or breaking up of a monopoly position*

Innovation is described more succinctly as the '*the transformation of knowledge into new products, processes, and services…*' (Porter and Stern 1999) and in the definition provided by the DTI in the Innovation Review as;

> "*…the successful exploitation of new ideas…*"

Information and knowledge (though of varying value and exclusiveness) are relatively abundant. However its potential is limited by '*the capacity to use them in meaningful ways*' (OECD 1996). The knowledge-based economy therefore applies 'Innovation' to turn knowledge into wealth.

Innovation is central to driving up productivity and delivering economic growth. Porter and Stern (1999), outlining how innovation not only provides a mechanism for improving productivity through efficiency, but also creates higher value goods for which businesses (subsequently amalgamated to industries and economies on a national scale) can command higher prices in comparison to the inputs required. If unskilled labour and land are cheaper in Asia and access to markets from these locations is relatively easy then it is through *innovation*, and the development of *higher value-added* goods and services that developed nations can compete (Porter 2000).

Innovation has often been approached as a linear process taking an idea through development and production to market, as in Fig: 3.17 (OECD 1996). Each of the phases in this model itself draws upon a variety of disciplines as illustrated in the 'Innovation Bridge' representation of Clement (2004) (Fig: 3.18).

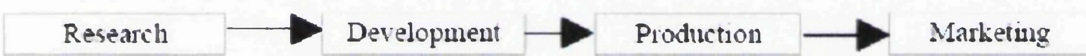


Fig. 3.17 'Linear' model of Innovation (OECD 1996)

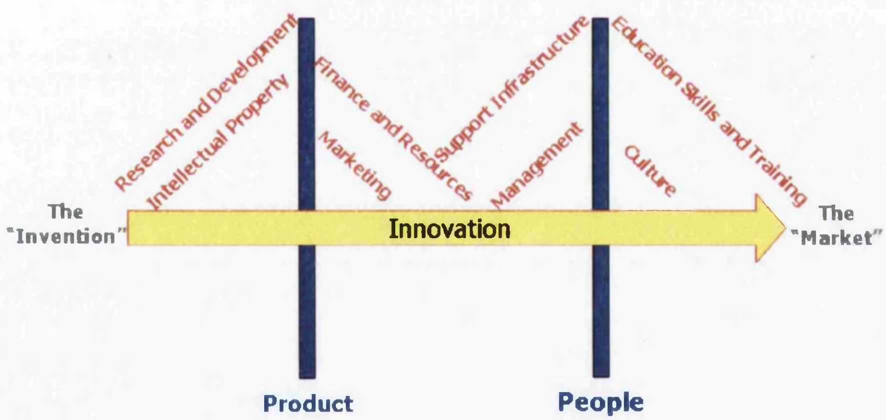


Fig. 3.18 'Innovation Bridge' linear model of innovation presenting disciplines involved (Clement 2004)

Such a model implies that innovation is only 'initiated' by invention or discovery (OECD 1997). This sits at odds with von Hippel's observation that the most important source of innovation is '*end-user innovation*' (von Hippel 1988) where users' needs rather than supply side factors drive the development and exploitation of knowledge. The 'chain-link model' of innovation by contrast allows for numerous stimuli and feedback to be incorporated from various stages between identifying market potential and actual sale (Fig: 3.19 over page).

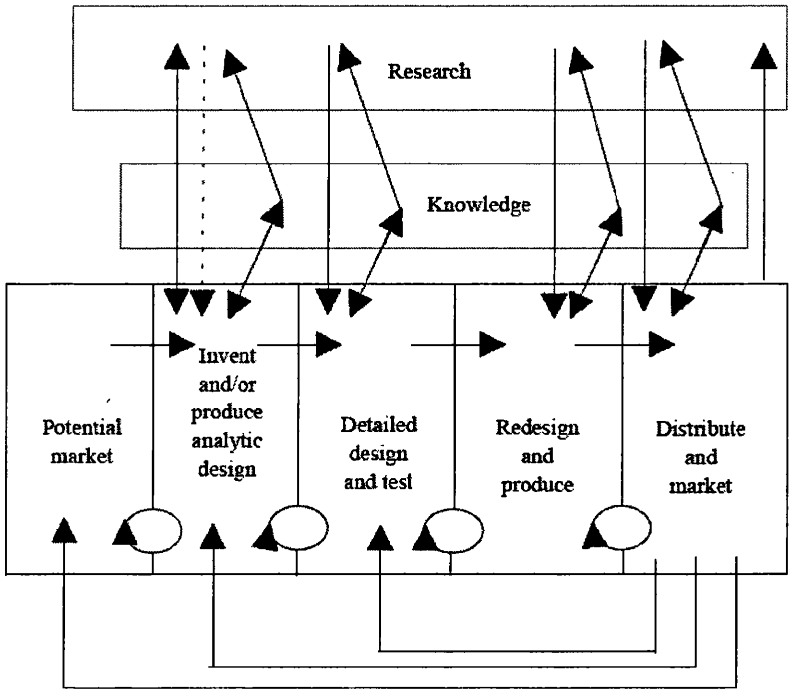


Fig: 3.19 'Chain-link' model of innovation (OECD 1996)

Innovation at the Firm Level

Innovation has been cited as a key determinant of macroeconomic growth, but does it relate to the microeconomic level? It has been shown by various studies that innovative firms outperform their peers who do not engage in the activity (Geroski and Machin 1992, Heunks 1996, Leadbeater 1999, Freel 2000).

This improved performance relates to growth in employment, turnover and profitability. Each of the studies listed above supported this broad linkage between innovation and performance, though each shed further light on different aspects. Freel (2000), in a survey of 228 small firms, found that innovation created growth in employment though not necessarily in profitability. This, as Freel explains, is understandable for the sunk costs of innovation will impact upon young firms prior to them enjoying returns on route to becoming larger firms. The earlier work of Geroski and Machin (1992) focused on larger companies. An interesting result from this study was that the fortunes of innovative firms were less cyclic than those of other firms. This runs against the hypothesis that cyclical introduction of new products would have a corresponding cyclical effect on performance.

Innovation can be difficult for businesses as it often involves change, the scale of which is generally related to how radical the innovation may be. This makes it especially challenging for larger businesses where practices are more embedded and changes more difficult to effect (Keeble and Tomlinson 1999).

Research and Development (R&D)

R&D is often used as a proxy measure for innovation activity (LeadBeater 1999, WAG 2001) though it is in effect simply an input to the process. However, outputs require inputs and this measure has readily available data for comparison at national and international levels.

The importance of R&D in driving innovation and economic development cannot be overstated. In 2002, at least a quarter of the UK productivity gap with the US was linked to lagging investment in R&D (DTI 2003).

However, the importance of public R&D activity should not be overlooked, particularly in developing new technologies. As pointed out by Porter and Stern (1999), information technology, telecommunications, weather satellites, sensors, passenger jets and many other technologies have come about from defence research. The private sector will understandably focus efforts where it can find returns, i.e. at the market, leading to greater interest in the development end of R&D. In the US for example, 70% of R&D expenditure is for Development, while 22% goes into exploratory and applied research, with the remaining 8% spent on basic research (OECD 1996).

Intellectual Property

Intellectual Property Rights (IPR) represents the mechanism through which individuals and organisations aim to protect and manage their knowledge. As described by Nelson (1980) IPR has the role of balancing the public and private interests of innovation providing "*...enough private incentive to spur innovation, and enough publicness to facilitate wide use...making public those aspects of technology where the advantages of open access are greatest*".

The strength of the IPR instrument is also a challenging issue in fostering the optimal level of competition. Monopoly capitalism feared earlier in the century was broken by competition, through constant new entrants to markets and innovation itself (World Bank 1999). However, IPR is intended to present a barrier to entry, allowing monopolistic positions to be established. The accessibility of levering IPR is also an important issue as costs of protection and enforcement are a particular challenge for smaller innovative companies (DTI 2003).

While R&D expenditure is an 'input' of the innovation process, patents are best regarded as an 'intermediate product'. At a macroeconomic level patent statistics generate an interesting picture of comparative productivity. Despite being by far the largest spender on R&D (42% of OECD R&D expenditure), the US produces relatively few patents compared to some of its competitors. France, Germany, Japan and the UK together create 83.6% of triadic (US, EPO and Japan patent office filed) patent families (OECD 2005). While this is an observation of the OECD, the researchers do not discuss whether this is a bias caused by attitudes of US companies towards overseas markets or whether it is simply that overseas countries need to access the significant US market.

3.3.3 Open Innovation

Open Innovation is a concept developed by Henry Chesbrough (Chesbrough 2003, Chesbrough 2006) recognising a change in how businesses innovate. The concept is defined by Chesbrough as being;

"*...the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. [This paradigm] assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology.*"

(Chesbrough 2006)

As the definition implies, Open Innovation is not only about where companies source knowledge for their own innovations but ways in which they manage innovations that arise which may not fit with the conventional strategy. Examples of both these strands may include licensing in IP to develop, while licensing out IP which may not fit with the core business.

Chesbrough outlines how the development of this concept is highlighted by the challenges faced by many major companies who are struggling to sustain their innovation performances. To address this they are having to look beyond their (often global) internal capabilities and engage in innovation with a variety of partners. Whereas internal R&D could produce sufficient innovation he describes how this has been challenged by '*erosion factors*' including;

- *The increasing availability and mobility of skilled workers* – i.e. the precious human capital they enjoyed is no longer exclusive and therefore a competitive advantage
- *The venture capital market* – i.e. the increased availability of investment has removed (or at least reduced) a barrier to entry for new competitors
- *External Options for Ideas Sitting on the Shelf* – i.e. the ability to 'spin-out' new products or services through alternative and/or new channels
- *The Increasing Capability of External Suppliers* – i.e. if the inputs to the company include more 'value-add' then the company can add less value

Many of the concepts in Open Innovation are not new. For example, earlier models of innovation describe how '*firms search for linkages to promote inter-firm learning and for outside partners to provide complementary assets*' (OECD 1996), which ties in with the paradigm described by Chesbrough. Furthermore, the pressure of the Knowledge Economy in challenging hierarchical structures and replacing them with flatter alternatives, often involving semi-autonomous teams is an effect that was apparent before Open Innovation (World Bank 1999).

The challenge for businesses to exploit external knowledge sources while 'protecting' their own knowledge is observed by Doring and Shnellenbach (Doring and Shnellenbach 2006) in their work examining knowledge spillovers.

The transition of multinationals to Open Innovation strategies is not only shown by high-profile endeavours such as Proctor and Gamble's 'Connect and Develop' strategy (Huston and Sakkab 2006) but also through observations of phenomena such as "*creation of new technological competencies through the international dispersion of corporate activities..*" (Cantwell and Piscitello 2005), whereby firms seek access to knowledge and opportunities in other localities.

The Procter and Gamble '*Connect and Develop*' strategy is particularly interesting as it uses an Open Innovation system to provide "*more than 35% of the company's innovations and billions of dollars in revenue*" (Huston and Sakkab 2006). Having previously focused on the internal efforts of its 8,600 scientists the company looked outside to capitalise on the 1.5million who worked elsewhere (Chesbrough 2003).

3.3.4 Innovation - Global, European and UK

By the end of the century R&D expenditure amongst OECD countries had almost doubled in real-terms since 1981 (Coates and Warwick 1999), however the rate of growth had slowed by the early 1990s and was starting, in real-terms, to decline (OECD 1999). This slowing in growth of R&D investment has been particularly acute in basic research, caused by freezing of government funding and cutbacks within the private sector for general research (OECD 1996).

Recognising R&D as a key driver for innovation, the European Union has set the objective of raising expenditure on R&D to 3% of GDP by 2010. If left to follow current trends by the end of the decade it would remain at 2.2% (EU 2005), just below the OECD average of 2.3% (OECD 1996).

As with 'knowledge' described in section 3.1.1, innovation is not constrained by national boundaries. Indeed greater innovation in one nation can enhance innovations created in others (Porter and Stern 1999).

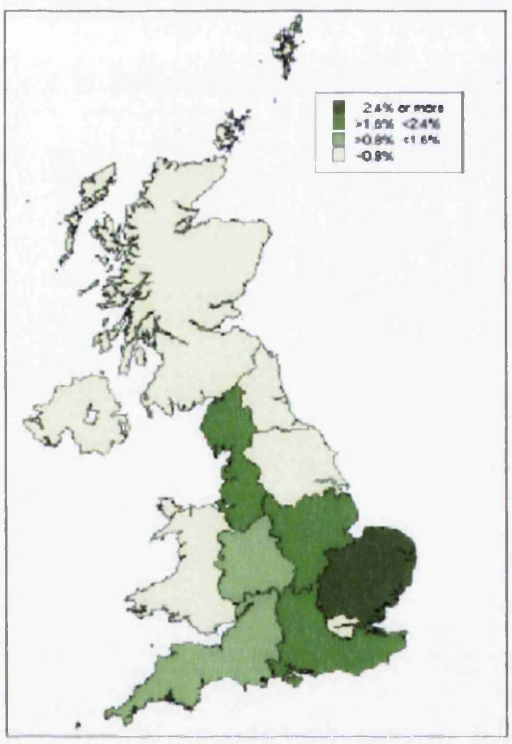
UK

The UK Government has put much emphasis on the promotion of Innovation to reduce the productivity gap with our major competitors. This was the focus of the Department of Trade and Industry '*Innovation Review*' undertaken in 2003 (DTI 2003). This resulted in actions to promote knowledge generation and dissemination, such as support to develop technology and knowledge transfer from academia along with tax incentives to support investment in R&D in the form of 'R&D Tax Credits'.

However, as outlined in a policy report (UK PM 2006) the picture for *exploitation* of knowledge remains mixed;

Positive Indications	**Negative Indications**
Indicators of business-university interaction are heading in the right direction	*The UK has failed to develop any major new technology-based companies in the past decade, with the exception of Vodafone which is essentially a service provider*
There has been significant growth in the number of medium-sized R&D intensive industries	*Total venture capital investment in early stage companies is not increasing*
The UK appears to be maintaining its strength in core R&D industries such as pharmaceuticals and biotechnology	*Business R&D may be increasing in real terms, but is not rising as a share of GDP*
International R&D is being attracted to the UK, and UK firms are investing in R&D abroad to access leading edge technologies from other markets	*UK ICT and electronics firms are restricted to niches of markets dominated by American companies built in the large and competitive US market*
	UK firms achieve fewer productivity gains from exploitation of technology than US competitors

Table: 3.7 Positive and negative indications of the exploitation of innovation in the UK, (UK PM 2006)



While many indicators for the UK are heading in the right direction and the picture for the country as a whole is encouraging this hides significant regional variation. This is highlighted in the statistics on regional expenditure on R&D as shown in Fig: 3.20 below, where levels of investment in the South East of the UK are significantly more than in other regions[8].

Fig: 3.20 Business expenditure on research and development (BERD) as a percentage of regional GDP (DTI 2001a)

[8] There exist doubts as to whether this information conveys a meaningful picture of innovation activity. This is discussed in further details in the following sections

3.3.5 Innovation - Welsh and Regional Context

Prior to the Objective One period, even though Welsh businesses accounted for 4% of the UK total stock of businesses, they accounted for only 1.2% of UK business R&D (WEFO 2004). This represented one of the lowest levels of R&D expenditure amongst UK regions (DTI 2001a).

This weak industry performance extends to the academic arena where Welsh HEIs possess far fewer SET research active staff than their UK counterparts as shown in Table: 3.8 below. As part of the evidence provided in the consultation to develop a science policy (NAW 2006), it was shown that in absolute values Wales ranks 11th out of the 12 UK regions for number of academic staff and 10th for proportion of research active staff. However, when presented per capita, Wales remains weak compared to the leading regions, though not as poorly as suggested by the absolute values.

Region	**No. SET Research Active Academic Staff**	**Rank**	**Per Capita SET Research Active Academic Staff (per 1000 population)**
Wales	1,170	10	0.40
London	5,375	1	0.71
Scotland	3,373	2	0.67
Northern Ireland	646	12	0.38
South West	1,423	8	0.29
South East	3,286	3	0.41

Table: 3.8 Academic Research Staff in Wales, Adapted from Excerpt of Review of Science Policy in Wales, Enterprise, Innovation and Networks Committee (NAW 2006)

Emerging evidence presents a more encouraging picture for Wales. 44% of businesses recently surveyed by the DTI Small Business Service reported that they had in the last year introduced significantly improved products or services, compared with a UK average of 35% (DTI 2005). This, in turn, builds upon an encouraging base of investment in innovation by businesses in Wales according to the 1998 CBI Innovation Survey (CBI 1998).

Wales has also performed relatively strongly in other more recent surveys. The 2001 Community Innovation Survey reported 37% of Welsh businesses as being active in innovation compared to 36% across the UK and 40% across Europe (DTI 2001). However, this apparently flattering headline figure must be treated with caution as it synthesises many variables including quality and type of innovation (e.g. process or product, groundbreaking or incremental).

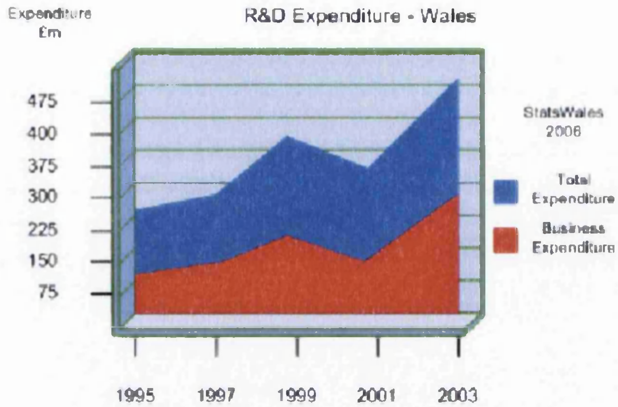


Fig: 3.21 R&D Expenditure in Wales

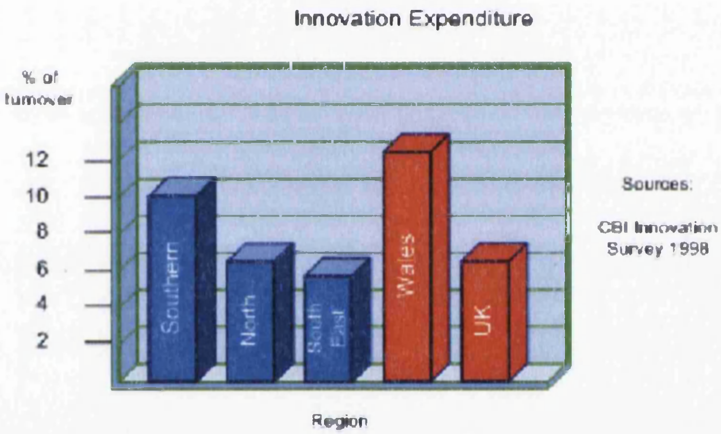


Fig: 3.22 Innovation Expenditure by Territory

The generation of new ideas, and protection and exploitation of Intellectual Property is central to the economic development strategy of the Welsh Assembly Government. The need for businesses to give greater focus to the commercial exploitation of ideas is clearly described in the Welsh Assembly Government's Action Plan for Innovation (WAG 2003).

"...proper protection and commercial exploitation of their intellectual property is something too few businesses consider."

In light of this the Welsh Assembly Government has worked to assist businesses in Wales in increasing their investment in R&D. Since 2001, Welsh Business R&D expenditure has increased to 0.7% of GDP from a base of 0.4%, though more progress needs to be achieved to break through the 1% target set in A Winning Wales (WAG 2005b). However, other surveys have shown that businesses in Wales fail to recognise the important role of innovation in helping them compete. Only 12% of respondents to a recent study by the Design Council saw innovation as a method to improve their competitiveness[9] (Design Council 2006).

The above presents an interesting picture of innovation in Wales suggesting that positive momentum is being developed, though from a weak base. This is encouraging though it should be acknowledged that, as described earlier, while Wales moves forward, so does its competition and therefore this momentum needs to be built upon and not simply sustained.

[9] Awareness of innovation drivers and attitudes towards the role of innovation amongst Technium firms form part of the study described in subsequent sections

3.4 Infrastructure

3.4.1 Infrastructure – Information Technology

To facilitate innovation and create clusters of growing knowledge-based businesses a supportive infrastructure is required. Infrastructure not only encompasses physical entities such as development facilities, offices and IT systems. 'Soft' infrastructure is equally critical. Important examples include enterprise support, specialist support such as legal services and the knowledge networks of individuals and organisations that disseminate and exploit knowledge and opportunities. These elements combine to underpin national and regional 'Innovation Systems'.

As described earlier the advent of modern Information and Communication Technologies (ICT) has been a catalyst to the development of the Knowledge Economy. Addressing the ICT perspective of building infrastructure for vibrant Knowledge Economies is recognised in the World Bank's KAM appraisal of assessing Knowledge Economy readiness amongst nations (World Bank 1998). It is also a key component of Knowledge Economy Strategies as the regional level (Scot Exec 2001a, WAG 2003).

Part of the step-change in developing the ICT infrastructure for the Knowledge Economy has been facilitated by the rapidly declining cost of equipment, as shown in Fig. 3.23 below, cited from Coates and Warwick (1999).

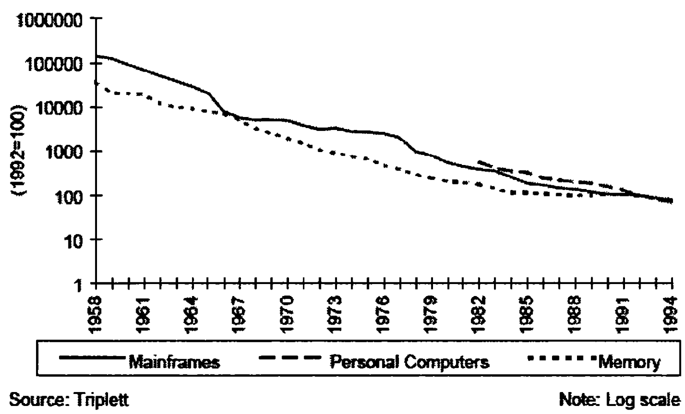


Fig. 3.23 Price of computer equipment in US (adjusted for quality) from Coates and Warwick (1999)

Fig: 3.23 above demonstrates the overall downward trend of computer equipment, but also features the advent of the personal computer, which truly revolutionised the dissemination of information and knowledge by giving individuals access to such tools on their desks both in the office and at home. Coupled with other developments including the emergence of the Internet and the proliferation of mobile phone networks ICT has become as fundamental to the Knowledge Economy as coal was to the Industrial revolution.

Within Wales the development of ICT infrastructure is central to its strategic planning as reflected in the Wales Spatial Plan (WAG 2004c):

"Develop ICT to provide innovative solutions for the delivery of public services, education and training and business opportunities locally. This needs to be complemented by strategies to ensure social inclusion and capacity building."

Wales has seen considerable improvements in its ICT infrastructure, such that over 99.5% of premises are connected to DSL-enabled exchanges (WDA 2001). The country is now the platform for the BT 21CN (21^{st} Century Network) development and initial rollout, placing it at the forefront of future ICT technology (BT 2006). This is an important development, as an increasing number of countries invest in developing their knowledge economies this is has raised the bar for the already developed economies (Porter and Stern 1999).

3.4.2 Infrastructure - Innovation Systems

National Systems of Innovation (NSIs)

Earlier in this section it was presented that innovation is more complex than a 'linear' model applied within businesses. This complexity extends beyond individual firms as knowledge flows both into and out of the organisation. The concept of an 'innovation system' was first developed by Lundvall in 1985 (Lundvall 1985), recognising the flow of information and technology in the innovation process between companies, their customers and other organisations. Though there exist many definitions of Innovation Systems (OECD 1997) they are broadly captured in that adopted by the UK DTI (2003):.

"...a set of actors (e.g. firms), institutions, markets and networks which jointly and individually contribute to the development and diffusion of new technologies"

As the word system implies this does not refer to a grouping of actors but also the ways in which they interact (OECD 1997). When considered alongside the definition of clusters described earlier in the chapter it is evident that innovation systems capture aspects of innovation activity within clusters. Innovation systems are regarded by government as important mechanisms through which they can act to support innovation (DTI 2003):

"(Innovation systems)... provide the framework within which governments form and implement policies to influence the innovation process."

(DTI 2003)

The strength of innovation systems can be determined through a number of critical success factors identified by the DTI (DTI 2003) and Porter and Stern (Porter and Stern 1999);

National Innovation System Success Factors

DTI	Porter and Stern
- *The capacity to absorb and exploit knowledge*	- *The size of the labor force dedicated to R&D and other technically oriented work*
- *The regulatory framework effects*	- *The amount of investment directed at R&D*
- *Competition regime and entrepreneurship*	- *The resources devoted to higher education*
- *Sources of new technological knowledge*	- *The degree to which national policy encourages investment in innovation and commercialisation*
- *Networks and Collaboration*	
- *Customers and Suppliers*	

Table: 3.9 National Innovation System Success Factors

Regional Innovation Systems (RISs)

Just as knowledge itself is not constrained by national boundaries, neither are Innovation Systems (OECD 1996). The above section has outlined innovation systems at a national level though the actors, factors and interactions of systems can not only reach across national boundaries but also exist in a smaller geography within regions.

Until the turn of the Century Regional Innovation Systems (RIS) were regarded as being relatively rare and a newly discovered phenomenon (Cooke 2001). The concept and discussion of examples in included in Cooke (1998). This includes a study of Wales where Cooke describes how the mix of inward investing and other firms interact to create innovative clusters. This study of Wales which Cooke builds upon in later work (Cooke 2001, 2002, 2006) focuses on industrial clusters including those in the electronics and automotive sectors.

Abbey et al. (2007) extends the concept in the Welsh context by considering a 'Sub-regional Innovation System' with the case of South West Wales, examining the role of the Technium Initiative. As part of their discussion they highlight the characteristics of vibrant regional networks, namely:

- the creation of strong local knowledge networks, proximity being important for such desirable traits as 'imitation, emulation and reverse engineering'
- the exploitation of the multi-disciplinary culture of a university
- the avoidance of path-dependent overspecialisation in increasingly obsolete areas of technology
- SMEs in different technological areas having their own interactive networks (effectively, therefore, separate technological ISs interacting with the spatial IS)
- large corporations seeking to externalise part of their R&D functions to SMEs that can act as intermediaries with universities
- the importance of developing extra-regional links
- the importance of producing highly qualified workers to support the labour market.

In light of these characteristics Abbey et al. (2004) discuss Technium *in* a Sub-regional Innovation System, rather than *as* itself being the system. This acknowledges the various linkages with related initiatives, including significant regional efforts such as the Institutes of Life Science and Advanced Telecommunications, and the wider multitude of system components.

3.5 The Third Strand of the Triple Helix – the Role of Universities

3.5.1 Academia in the Knowledge Economy

The linkages between academia and industry have received much interest over recent years by governments (WAG 2004, Lambert 2003), academics (Nelson 1986, Varga 2000) and other organisations including the private sector, though many commentators observe that it is the private sector which will deliver the fruits of innovation in the knowledge economy (Porter and Stern 1999).

The above studies recognise the importance of universities and academic knowledge in driving innovation and the knowledge economy. Nelson (1986) was one of the earliest to clearly demonstrate the positive effect of university on industry and technological advance, based on research undertaken in the US. This came at a time when American academia was undergoing the start of a seismic shift in technology transfer following the Bayh-Dole Act. This important pieced of legislation is regarded as a paradigm shift in US academia-industry relations for it clarified ownership of IP developed during research, and incentivised and charged universities to exploit its value.

Higher education institutions (HEIs) and public research facilities play a variety of roles in supporting the Knowledge-Based economy including '*knowledge production*' developing new knowledge, '*knowledge transmission*' – in developing human capital, and '*knowledge transfer*' – by disseminating knowledge and supporting industry (OECD 1996, WAG 2004). HEIs are also recognised as important knowledge businesses that are often 'anchor tenants' in regional knowledge economies (WAG 2004). The importance of HEIs in supporting knowledge-based industrial clusters in their regions is acknowledged by the UK and Welsh Governments (DTI 2001 and WAG 2003b).

Universities as Knowledge Businesses in Wales

The most notable contribution of Higher Education to the Knowledge Economy is the graduates it produces. The graduate outputs of Welsh Universities are a significant source of knowledge and skills. The Welsh HE sector employs over 17,000 people and is currently educating over 120,000 students, including some 45,000 in Science and Engineering. Additionally, the Welsh HE sector also supports a further 23,600 jobs in the wider community (HEFCW 2006).

Welsh Graduate Output – Welsh Economy Input?

However, the challenge exists, as described in the Welsh Assembly Government's Knowledge Economy Nexus (WAG 2004), to provide opportunities for these skills, preventing them from being lost to other regions of the UK. This outflow of graduates from most regions is something seen across the UK with young talent attracted to the opportunities of London and the South East of England. This problem is particularly acute in science and technology. While Europe (and our region) performs well in producing science and technology graduates we perform poorly in the number of researchers that we employ (EU 2006), thereby failing to capitalise on this investment in intellect.

3.5.2 Supporting Innovation – Knowledge and Technology Transfer

Universities are being increasingly recognised as a source of ideas for new commercial products and services (Siegel et al. 2002). University research produces new knowledge and builds upon existing knowledge. This makes it valuable for fuelling innovation, through both incremental improvements to existing technology and by major fundamental breakthroughs.

Forms of technology and knowledge transfer that are simple to measure and compare include: contract research; new company spinout; (Di Gregorio and Shane 2003); patenting and licensing activity. Each of these activities is easily numerated, be it by research income, number of new companies founded, patents filed or licenses executed. Studies in many countries, including extensive national surveys, have quantified and analysed these outputs of technology transfer (AUTM 1995, 2005, HEFCE 2003).

Consultancy, Contract Research and Licensing

As described above there exists a host of mechanisms for universities to transfer knowledge to the industrial community. Consultancy can provide businesses with the opportunity to appraise what a university could offer before embarking upon larger research contracts, leading to a different type of interaction, plus it can provide SMEs with university expertise for relatively low fees. Other fields of technology transfer could also benefit such as licensing, where more than 50% of licenses go to companies already known by the academic concerned (Lambert 2003).

The manner in which universities manage their IPR portfolios and anticipate revenues is an important issue. Using a portfolio of patents (patent pooling can be within and between institutions) (Parish and Jargosch 2003) in a targeted manner rather than relying on individual patents is a strategy advocated and applied by the Association of University Technology Managers (AUTM) in the United States. This strategy helps facilitate successful licensing and commercialisation. This strategy also helps balance revenues, as revenues from all patents are not equal. During 2002 only 0.6% of licenses negotiated by U.S. universities (n.b. licences not patents) provided revenues of over $1million (Pressman 2002). When considering the possible revenues it must be born in mind that on average it takes six years to commercialise university research, thereby putting much of the onus of risk and investment onto the shoulders of the licensee.

Management of IP raises many issues before embarking upon the patent application process and searching for potential licensees. The appropriateness of patent protection, and to what extent are important considerations along with ensuring freedom to operate. 70% of R&D in the U.S. infringes IPR of another party (Thomson Derwent 2004), which can place substantial obstacles in the path of continued the development, let alone eventual commercialisation. The importance of the right of freedom to operate in the university case has been highlighted by high-profile cases such as Madey vs. Duke University (Guttag 2003) in the U.S. and has led to much discussion about the legal position of educational institutions.

Historically Welsh HEIs have engaged in a limited amount of licensing activity with more focus given to development of spin-out companies. However, there have been instances where inventions have been licensed for significant sums. The most notable example concerns a life science technology relating to fluorescence technology used in genetic research, which was licensed by the University of Wales College of Medicine for £710,000 (WAG 2004).

While licensing activity has been modest other mechanisms such as consultancy have been growing consistently since the mid 1990's as shown in Fig: 3.24 below:

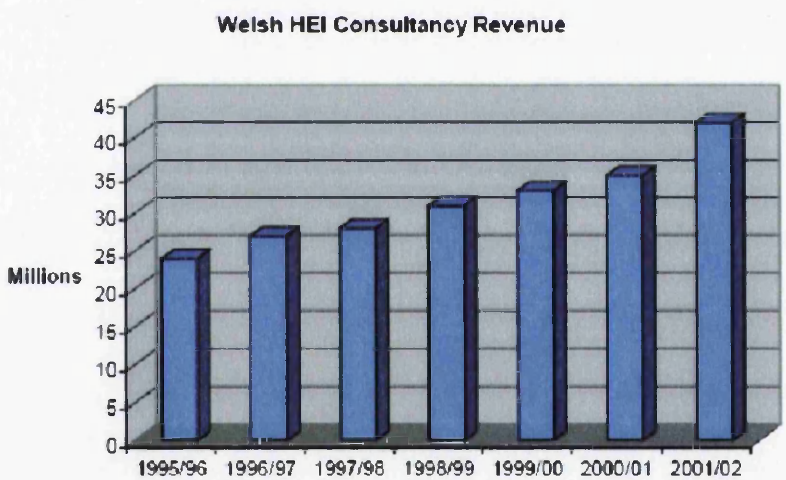


Fig: 3.24 Consultancy Income of Welsh HEIs 1995-2002 (WAG 2004)

Spin-out Companies

Furthermore companies located in university incubators have been found to be more productive (Siegel et al. 2003) along with the sense of vibrancy and catalysing effect they have for associated companies. This can assist in long-term economic development supporting the establishment and growth of successful clusters (Tornatzky 2000).

Welsh HEIs have been performing well in terms of creating spin-out companies. During 2001/02, supported by the Wales Spin-out Programme, 22 spin-outs were produced (10% of the UK total) together with a further 64 businesses started by graduates (19% of the UK total). This performance is particularly encouraging considering Wales represents 6% of the UK population.

However, the rate of spin-out development in Wales stuttered following this period, as it did across the whole of the UK, following changes in capital gains tax rules in 2003. These rules saw academics being liable for immediate taxation at a rate of 40% on the value of their share of equity in a spin-out company. This issue is now being addressed by the Treasury together with professional bodies representing academic commercial activity such as The University Companies Association, UNICO (2004).

4. Developing Knowledge Enterprise

As described in Chapter 2, and in more detail in the following Chapter, the purpose of Technium is to support the development of knowledge-based enterprise in South West Wales. This Chapter discusses the concept of Knowledge Enterprise. Sections 4.1 and 4.2 focus on the development of indigenous knowledge-based businesses, while section 4.3 examines the role of business incubation.

4.1 Entrepreneurship

4.1.1 Entrepreneurship and Economic Development

Entrepreneurship is a key driver of economic growth (Schumpeter 1934, Rocha 2004, Wong et al 2005) and is often simply referred to as the practice of forming new organisations or the creation of new economic activity. However the link between these two concepts can be traced back to Schumpeter who describes 'entrepreneurial profit' as being quite simply – "*a surplus over costs*" (Schumpeter 1934), recognising the "*outlay*" or investment by the entrepreneur and the premium he should expect to receive for undertaking the risk of the activity. The formation of new businesses provides opportunity for entrepreneurs and generates new possibilities for the labour market (WAG 2000).

The measurement of entrepreneurship often focuses on the number of new start-ups, with business churn of VAT registrations and deregistrations providing a readily available index (Keeble and Walker 1994). However, the concept of entrepreneurship has been expanded to reflect the fact that the process typically involves more than a 'sole entrepreneur'. An example of this is the measurement of Total Entrepreneurial activity used by the Global Entrepreneurship Monitor (GEM) study. This study develops a picture of entrepreneurial activity beyond levels of business start-ups and registrations, by investigating other involvement and attitudes towards entrepreneurship.

Business incubation plays an important role in entrepreneurship by providing an environment to support entrepreneurs (Allen and Rahman 1985, UN 1999, Aernoudt 2004). The manner in which business incubation has developed over recent years is the focus of the following sections.

4.1.2 The Case of Wales

Wales has performed poorly relative to the UK both in terms of new business start-ups and businesses per head of population (WAG 2001). This is borne out by a rate of new business formation 30% behind that of the UK as a whole in 1999 (WAG 2000). This is, to a certain extent, a relatively recent trend as during the period 1980-90 Wales had been keeping in touch with UK performance, as shown below in Fig: 4.1 though this encouraging rate of new business formation was accompanied by a high level of companies being dissolved (Keeble and Walker 1994). Improving the level of entrepreneurship is key to the WAG strategy to bring economic performance closer to that of the UK and EU (WAG 2001, WAG 2000, WAG 2004).

	New firms (000s)	New firm formation rate[1]	Net growth in firms (000s)	Net firm growth rate[1]
South East	850	100·3	193·4	22·8
South West	190	99·7	41·4	21·7
East Anglia	79	95·8	17·9	21·7
East Midlands	140	79·3	28·1	15·9
Wales	93	77·5	16·5	13·8
West Midlands	180	72·1	32·7	13·1
Yorkshire and Humberside	158	70·3	24·3	10·8
North West	207	68·7	23·8	7·9
Northern Ireland	39	61·1	9·3	14·5
Scotland	134	55·4	21·7	9·0
North	77	55·3	11·0	7·9
United Kingdom	2,147	81·4	420·4	15·9

Note: 1. Per 1,000 civilian labour force, 1981.
Source: VAT business statistics from DALY, 1991.

Fig:4.1 Regional new firm creation rates (Keeble and Walker 1994)

Since 1999 there has been much effort in encouraging entrepreneurship, particularly in Knowledge Economy sectors and our Spatial Plan region. Many programmes have been run to encourage new business formation, some of which have been aimed specifically at under-represented groups including students, ethnic minorities and women. Signs of success have included the fact that in 2002 Wales accounted for some 19% of UK graduate start-up companies (HEFCE 2003), compared to its 6% share of UK population.

The National Entrepreneurship Observatory in Wales co-ordinates a number of indices and studies within Wales tracking business growth and performance, with specific focus on new businesses. The Centre also manages the national 'Global Entrepreneurship Monitor (GEM) for Wales' project, as part of the world's largest study of entrepreneurship. This study uses the 'Total Entrepreneurial Activity Rate' (TEA) index (GEM 2004). Using the TEA measure, Wales performs relatively well compared to our European neighbours, though still lags somewhat behind the US and other highly entrepreneurial countries such as Singapore (GEM 2004).

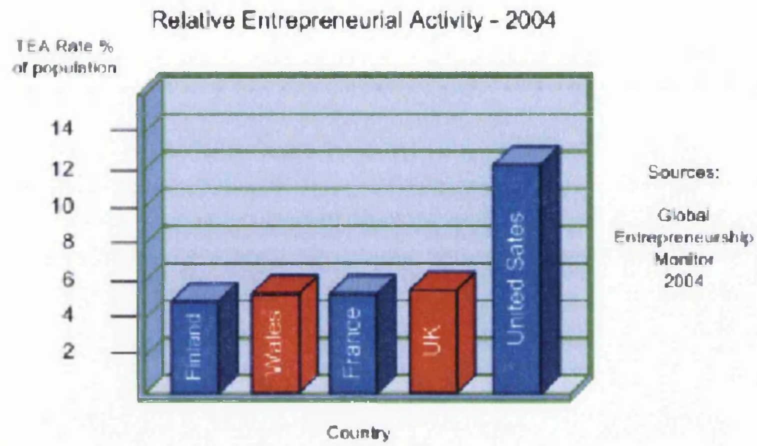


Fig: 4.2 Relative Entrepreneurial Activity by Country (GEM 2004)

While the performance of the Swansea Bay, Waterfront and Western Valleys Spatial Plan region has improved over recent years it still lags behind the Welsh average. This disparity is also highlighted by other indicators. In Neath Port Talbot for example only 6.5% of the population are self-employed, compared to the Welsh average of 12% (ELWa 2005).

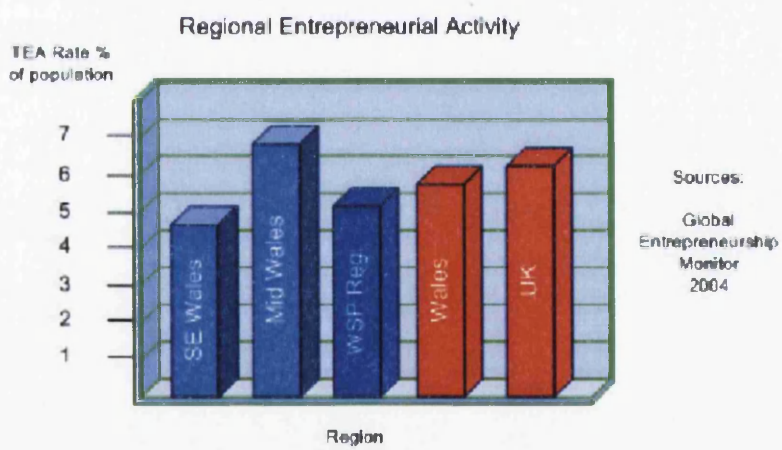


Fig: 4.3 Relative Entrepreneurial Activity by Region (GEM 2004)

WAG funded programmes including the Knowledge Exploitation Fund (KEF), Wales Spinout Programme and Graduate 2 Enterprise (G2E) have targeted the development of knowledge businesses, particularly those stemming from academia.

4.2 Knowledge-based Businesses

The nature of knowledge enterprise has changed significantly over time moving from lone inventors such as Thomas Edison to huge research labs such as those operated by Bell or AT&T (World Bank 1999) to the new phenomenon of Open Innovation described in Chapter 3. Small knowledge-based businesses play an important role in this phenomenon, as many are started specifically to chase the promise of a new technology or way of doing something, making them inherently innovative (Almeida and Kogut 1997).

The role of small businesses, both in the knowledge and wider economies, in Europe's economic growth is acknowledged in the European Charter for Small Enterprises:

"*Europe's competitiveness depends on its small enterprises: these are the main drivers for innovation, employment...*"

(European Charter for Small Enterprises, EU 2000)

Chapter 3 discussed the innovation process and the knowledge types that businesses need to manage and exploit. This highlighted the importance of external sources of knowledge, both codified and tacit, from an economy or sector level perspective. At the firm level it is important to consider the ability of a business to 'absorb' this knowledge (Keeble and Tomlinson 1999). This requires that a business has certain internal skills and its own capacity for research and development in order to exploit value from knowledge.

The potential competitive performance of a business is determined by its technical, marketing, managerial and other capabilities (Keeble and Tomlinson 1999). This underlines that for a business to truly succeed it needs more than a great manager, a fantastic idea or a prime market; its needs them all – whether it finds them internally and/or externally.

The importance of regional networking was discussed earlier in Chapter 2 with regard to 'Clusters', 'Knowledge Spillovers' and 'Regional Innovation Systems'. This effect is of particular importance to indigenous companies as this '*local sticky*' knowledge (Asheim and Isaken 2002) can be an important part of their competitive advantage, whereas larger firms may have an armoury of other assets (Almeida and Kogut 1997).

4.2.1 Small Indigenous Knowledge Enterprise

The importance of new and small technology-based firms has increased as economic development shifts to a '*grow your own*' strategy to develop new opportunities (NBIA 2003). This is reflected in the changes seen in Wales and discussed in Chapters 1 and 2, and is reinforced by the overall importance of small businesses. For example, between 1969 and 1976 small businesses accounted for around 80% of new employment. However, these include many companies enduring challenges that see 75% of small firms fail within their first five years (Lewis 2001).

High-technology industries are typically dominated by large firms (Hughes 1999). However, the role of small and medium enterprises must not be neglected or misunderstood as they can be particularly adept at exploiting technological change and grow quickly (Jovanovic 2001).

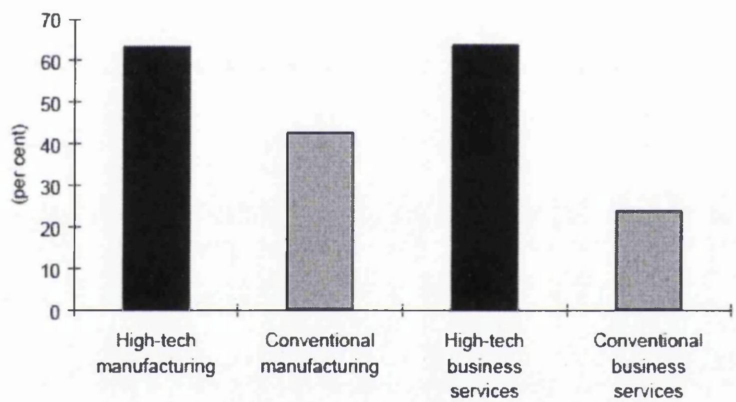


Fig: 4.4 Proportion of SMEs carrying out R&D – 1997, Hughes (1999)

Fig: 4.4 highlights part of the challenge of 'missing innovation'. As Hughes observes, the fact that some 42% of non-high-tech manufacturing and 25% of non-high-tech services companies are undertaking R&D shows how innovative efforts are not the preserve of the 'high-technology' sector.

The important potential contribution to the economy of developing indigenous enterprise is highlighted in the 'FastGrowth 50' index of Welsh businesses. The index tracks the fastest growing independent or privately held SMEs in Wales (Western Mail 2005). While relatively few of the companies are based around cutting-edge technology, most are innovative in the products or services they offer, or the way in which they access/engage with their markets.

While growth of employment and profitability are traditionally used as indicators of success other factors are also used such as ability to attract investment, survivability etc. (NCEA 2004).

Success Factors

New enterprise, particularly new technology based firms (NTBFs), face a multitude of challenges in their development. Business incubation, which is discussed later in this section, aims to assist companies in facing these challenges. A number of factors that affect a business's ability to succeed have been identified by studies including: professional expertise (of both the entrepreneur and available in the region); linkages with other companies; local enterprise culture and others (Keeble and Walker 1994, Almus and Nerlinger 1999, Kakati 2003). These studies have examined factors both internal (such as management) and external (such as macroeconomic factors) to businesses. A key challenge in identifying reasons for business failure (or success) is to avoid the bias amongst entrepreneurs in understanding and/or reporting the relevant factors of success or failure (Rogoff et al. 2004). This is especially important as the entrepreneurs themselves are one of the critical factors (Kakati 2003).

The study conducted by Kakati (2003) is particularly interesting in that it examines the experiences of a number of venture capital firms, actors who have seen a multiplicity of both success and failure and who will comment without the bias that may exist amongst the business founders. The findings of the study stress the importance of entrepreneur quality in determining the potential for success. Factors resulting in failure are typically the inverse of the success factors. These challenges that threaten success or tempt failure, including: lack of capital, poor managerial skills and insufficient understanding of the marketplace (Lewis 2001).

The role of business support in addressing many of these challenges has received particular interest. For example, it has also been shown that businesses which obtain advice on issues such as business strategy and staff recruitment are more likely to succeed (Robson and Bennett 2000). However, the value of external government support is questioned by some studies (Robson and Bennett 2000, Westhead and Birley 1995).

The readiness of SMEs to seek or accept public-sector provided support appears to depend on their perception of the knowledge or expertise of the provider (North et al. 2001). This suggests sceptical thinking along the lines of, '*those who can…*'. Addressing this issue is something at the heart of mentoring schemes, whereby an experienced current or former entrepreneur provides support and advice.

Intangible Assets and Raising Finance

A key challenge to developing new enterprise is the availability of capital (World Bank 1999). In the case of knowledge-based firms this can be compounded by the fact that much of their value is tied up in intangible assets in the form of patents, know-how etc. In the US for example, the ratio of market-to-book values of technology firms during the 1990s was on average greater than 10 (Leadbeater 1999). Leadbeater describes a number of avenues for addressing this challenge, including;

- evaluation of 'replacement cost' of the intangible asset
- 'income projections' for products or services based on the intangible asset
- 'market valuations' of what someone would be prepared to pay for the intangible asset

Each of these has its own limitations. Market value for example is particularly difficult. Often an intangible asset such as a patent may have only a limited market and be of value only when accompanied by other intangibles.

R&D can often be at the heart of a small knowledge-based business though conventional accounting sees R&D simply as a cost rather than an asset (Leadbeater 1999). This can make a small R&D-intensive business look as if it is burning a lot of cash while returning little to its balance sheet. The problem can also be further compounded where ownership to IP involved is unclear, and in particular when considering technology far from market, as is often the case with university inventions (Davies, Abbey and Clement 2007)[10].

[10] This work is included as Appendix 3

4.3 Incubators, Knowledge Parks and Science Parks

4.3.1 History and Concepts

While Aernoudt (2004) traces 'incubation' back to its European roots, the concept is regarded as having first developed in the United States with the first commonly recognised incubator being the Batavia Industrial Center, which opened in 1959 (NBIA 2007). The New York incubator, created in a disused factory, reflected the generally low tech and service sector focus of many of the first incubators. Over the coming decades the growth in the incubation movement remained modest with only a few dozen programmes worldwide by the early 1980s (NBIA 2003), compared to over a thousand around the world today (Aernoudt 2004).

Defining the concept of incubation is itself a matter of debate, as described in Chapter 5. For present purposes, the US NBIA definition of incubators and science parks is used;

"*...an economic development tool designed to accelerate the growth and success of entrepreneurial companies through an array of business support resources and services. A business incubator`s main goal is to produce successful firms that will leave the program financially viable and freestanding...*"

(NBIA 1999)

As described in Chapter 4, Technium, which embraces a range of businesses including inward investors, is captured by the definition above, while other definitions focus solely on small or newly formed businesses.

One point that needs to be recognised is the manner in which the terminology 'incubator', 'science park' and 'research park' often overlap. While 'park' may conjure up images of vast spaces, incubators are generally included within the 'park' concept. Luger and Goldstein (1991), for example, in their work on research parks, say that;

"*...Business incubators that provide space in multitenant buildings for new small businesses may also be included under this definition* (of research parks) *if those businesses are R&D-oriented...*"

This is consistent with the fact that individual Technium Centres are members of the UK Science Park Association. Furthermore, with regard to the issue of scale, the employment of Technium Swansea alone is greater than that of the majority of 'parks' included in the study by Luger and Goldstein (1991).

Hackett and Dilts (2004a) describe incubation as a process that takes inputs to produce 'outputs' of incubated companies that result in a range of outcomes as part of a simple model. These inputs and outcomes are as shown in Table: 4.1 below (though with no specific relationship across rows);

Inputs	**Outcomes**
Entrepreneurs	Incubatee is surviving and growing profitability
Enabling Technologies / Innovations	Incubatee is surviving and growing though not yet profitable
Critical Technologies / Innovations	Incubatee is surviving but not growing and not profitable/marginally profitable
Strategic Technologies / Innovations	Incubatee operations terminated while still in the incubator; losses minimized
	Incubatee operations terminated while still in the incubator; large losses

Table: 4.1 Inputs and Outcomes of Incubation – Adapted from Hackett and Dilts (2004a)

The inputs can originate from various sources including basic research and entrepreneurship activities. The model extends to intermediate outcomes of viable/becoming viable companies and dead/dying companies along with long-term outcomes of addition to the overall business stock.

As the stock of business incubators has grown, so their nature has also evolved. What was typically managed workspace has developed into sector-focussed facilities that can be 'without walls' or even virtual. An example of this is Technium Associate Membership, which provides incubation support services to companies who are not Centre tenants.

The evolution of these concepts is presented in Fig: 4.5 from Hannon (2005) below;

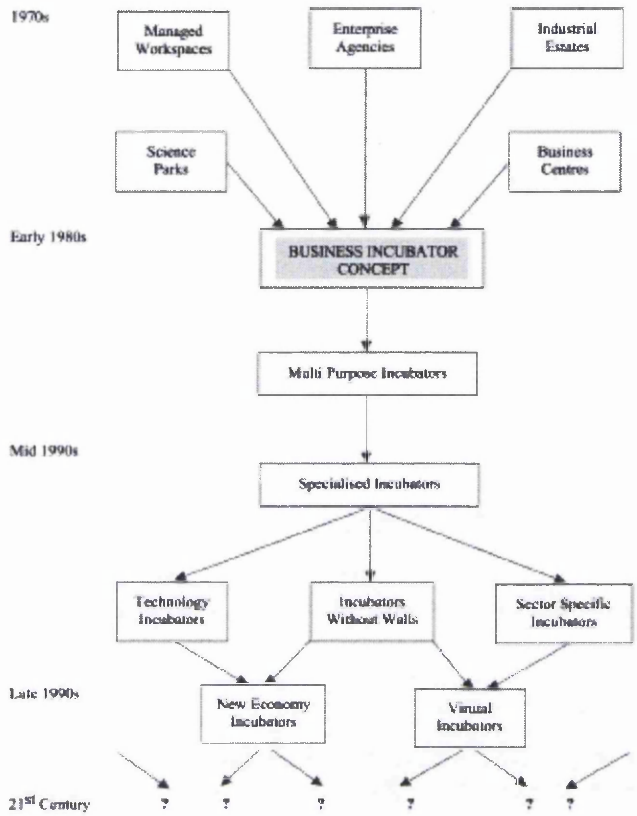


Fig: 4.5 Evolution of Incubation – from Hannon (2005)

The multitude of different incubator models is also reflected in the wide array of international and national organisations supporting business incubators of all types. These include;

- The International Association of Science Parks (IASP) – International membership though primarily European (IASP 2007)
- The National Business Incubation Association (NBIA) – International membership though primarily US (NBIA 2007)
- The Association of University Research Parks (AURP) – representing an International membership of research parks affiliated with universities (AURP 2007)
- United Kingdom Business Incubation (UKBI) – UK organisation supporting the development of business incubation (UKBI 2007)
- United Kingdom Science Park Association (UKSPA) – UK organisation supporting the development of science parks

Along with the development of support organisations, the evolution of different incubator models has led to much interest in comparison of models and practices (Mian 1996, Nowak and Grantham 2000, Cooke et al. 2003, Cooke et al. 2006). Typologies of incubator are discussed later in this section.

Research regarding the role of science parks in assisting the development of NTBFs has come to different conclusions. For example, the work of Löfsten and Lindelöf (2002) comprising analysis of 273 firms in and outside parks in Sweden, finds that growth of NTBFs inside parks is "*..substantially higher than for NTBFs in general or conventional small firms.*". Meanwhile, Siegel et al. (2003) in their study of UK science parks, find the economic returns of parks appear to be '*negligible*', though acknowledge this may be due to '*imprecise*' estimates of returns. One of the issues highlighted by Siegel et al. is the need to properly compare the development of companies in parks with those outside[11].

The UK Incubation and Science Park Movement

Science Parks and Technology business incubation in the UK is commonly regarded as having started in the 1970s with parks developed by Trinity College Cambridge and Heriot-Watt University, followed by a second wave of developments in the 1980s (Edmonds 2000).

The following years saw a strong and consistent growth in science parks, as shown in Fig: 4.6 below, with 40 parks around the UK by the end of the 1980s and over 60 parks today, employing over 41,000 people (UKSPA 2003).

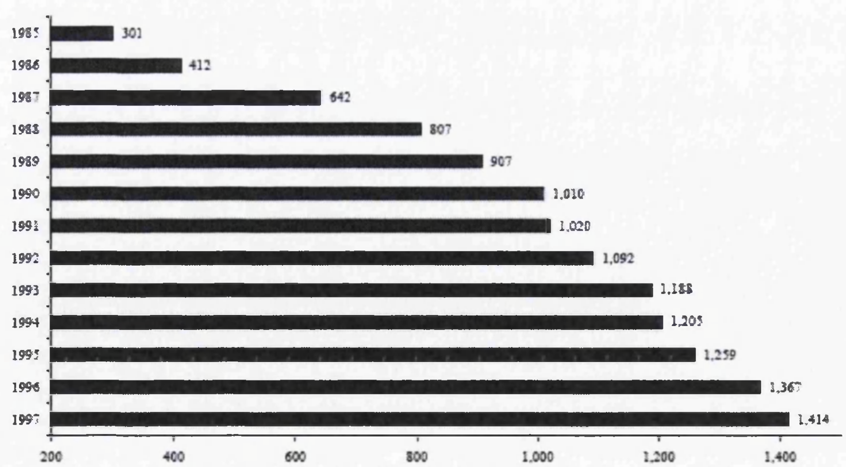


Fig: 4.6 Number of tenant companies in UK Science Parks 1985-1997 (Edmonds 2000)

[11] Such an approach is developed in this study, comparing Technium companies with others outside the network

Despite this increase in the number of science parks, the growth of knowledge enterprise around the UK was restricted by market failure in provision of such facilities. A 1998 KPMG survey (Science Parks & the Growth of High-Tech firms, cited from Edmonds 2000) observes;

"Despite the expected higher rates of return from 'high-tech' premises, there has been a virtual absence of provision by the private sector outside south-east England. This reluctance of the private sector to provide suitable premises for technology based industry meant that public sector organisations, such as local authorities and government development agencies, committed themselves to filling this gap"

The increasing interest in business incubation as an economic development tool is reflected by numerous studies examining its effects on business development and on economies at both regional and national levels (Luger and Goldstein 1991, NBIA 1999, NBIA 2003, UKSPA 2003).

4.3.2 Incubator Roles, Types and Practices

Companies in business incubators have often been found to develop at a faster rate, innovate more, have greater access to funding opportunities and attraction of staff and customers than those located outside (Löfsten and Lindelöf 2002, UKSPA 2003, Aernoudt 2004). The survivability of firms has also been shown to be greater inside incubators (Lewis 2001). Incubators can also play a role in providing a focus for the knowledge interface between research institutions and the private sector (Cooke et al. 2006), and greatly increase the chances of a firm remaining in the locality post incubation (Lewis 2001).

Public and Private

Earlier sections have discussed the development of knowledge-based businesses and their incubation in the economic development context. Incubation is not solely a public sector endeavour; a large number of private sector incubators are also in existence. An example of private sector involvement exists in certain Centres of the Technium network. Technium OpTIC and Technium CAST, both located in North Wales, were developed by the public sector, but are now managed by SERCO, a private sector company renowned for its involvement in all manner of public 'services' including prisons and motorist speed traps (Serco 2007).

The implications of the public and private models have been considered by numerous observers (Nowak and Grantham 2000, Cooke et al. 2006). The mission of incubation to "*...produce successful firms that will leave the program financially viable and freestanding...*" (NBIA 1999) would seem to fit poorly with traditional private property development ambitions of anchoring long-term tenants to provide stability of rental income. Indeed, 'best practice' guidelines suggest that incubators should not be operated at above 85% capacity (CSES 2002) (see following section).

Some observers such as Lewis (2001) argue that many privately-run establishments do not qualify as incubators, but rather as straightforward real-estate ventures. However, the relationship between the 'private' developer and tenant may extend beyond letting of serviced office space to include other paid-for services and even to taking an equity stake in the company. Contrary evidence is provided by Grimaldi and Grandi (2005) in their study of Italian incubators. They found that companies stayed longer in public rather than private incubators.

Technology Incubators

Another distinction is made between general incubators and those with a focus on technology or knowledge-based firms. Many incubators are developed with a specific focus (see Fig: 4.5, p. 91) and often have tenant selection criteria (as does Technium) to preserve this. Whereas the earliest incubators nurtured relatively low technology businesses, a new wave of technology-based incubators is growing both in number and importance (NBIA 2003). Lewis, in his study conducted for the US Economic Development Administration, 'Does Technology Incubation Work?' (Lewis 2001) suggests that an incubator can be classed as 'Technology-based' if over 50% of firms are technology-led. However, he acknowledges the challenge in consistently defining whether individual firms satisfy this criterion. His study observes differences in US technology incubators compared to general incubators including smaller firm size, longer time to graduation (through longer development) and support of innovation through cross-fertilisation of ideas between companies.

Practice – Bono, Melior et Optimus?

A number of studies and organisations have worked on identifying, developing and disseminating 'good' and 'best' practices for business incubators and science parks (UN 2001, CSES 2002, NBIA 2003, UKSPA 2003). The NBIA survey conducted for the US Department of Commerce (NBIA 2003) of business incubation in the US sought to establish the strength of any correlation between 'Best Practice' and performance. In this regard, the study found the most important success factor related to the strength of linkages between the incubator and other regional organisations. These linkages related most importantly to organisations such as universities and public laboratories, but also a wider range of actors including accountants, patent attorneys etc. The importance of linkages also features in the best practice identified by other observers and organisations. One other core good practice is for an incubator to have a clear plan and a defined market (CSES 2002).

The criticality of the incubator manager is often highlighted by studies and the development of management skills is key to the success of the incubator (CSES 2002, Hannon 2005). This relates not only to supporting the development of businesses within the incubator, but also to developing the incubator itself as a business (Hannon 2005).Other practices identified include managing the investment of different resources into incubated firms at different phases of their development (Hackett and Dilts 2004a) and ensuring that incubators are run at no more than best practice of 85% capacity (CSES 2002). The latter implies obvious challenges for the private sector, where operating at below capacity is missed revenue. Lewis (2001) has identified the leading reasons for incubator failure as including; inflated expectations, selection of the wrong manager, overestimation of the incubator's role in an economic development plan, overspending and failure to leverage resources.

5. A Brief History of Technium

While Technium is a pan-Wales initiative, this study examines its development in South West Wales, focusing on those Centres associated with the University of Wales Swansea. This Chapter focuses on the initiative itself, building upon the background and context provided by earlier Chapters.

Sections 5.1 and 5.2 provide an overview of the 'Technium Concept' and the network of Centres in South West Wales. Section 3 describes the manner in which the network involved together and how it is currently managed. Finally, Section 5.4 describes some of the observations of Technium made to date, by academic and other observers.

5.1 The Technium Initiative in South West Wales

The Concept

Technium South West is a network of inter-related business support centres which are intended to support the development of innovative knowledge-based companies. The Technium initiative started at the end of the Objective 2[12] funding period in 1999 and has since evolved into a network of centres supported in part by the University of Wales Swansea with the concept also being adopted elsewhere in Wales. The ambition to develop further incubators in Wales based upon this model can be traced back to '*A Winning Wales*' (WAG 2001).

The mission of Technium in South West Wales is to;

"*...incubate a sustainable Knowledge Economy in Wales through the stimulation of innovation and the development of strong regional economic clusters*"

(Technium SW Steering Group 2005)

The Technium Centres are designed to co-locate knowledge-based businesses with specialist business support and facilities, along with links to academic expertise and centres of excellence, as shown in Fig.5.1 (over page). Each Centre has been developed as a partnership between public, private and education sectors. Private sector partners include multinational technology

[12] Objective 2 was the second highest level of economic development assistance available at the time. Prior to 1999, Swansea and therefore the original Technium project fell within an assisted area.

based firms and knowledge services such as legal and financial who provide support to companies involved in the initiative. The Centres in the South West are described in the following sections.

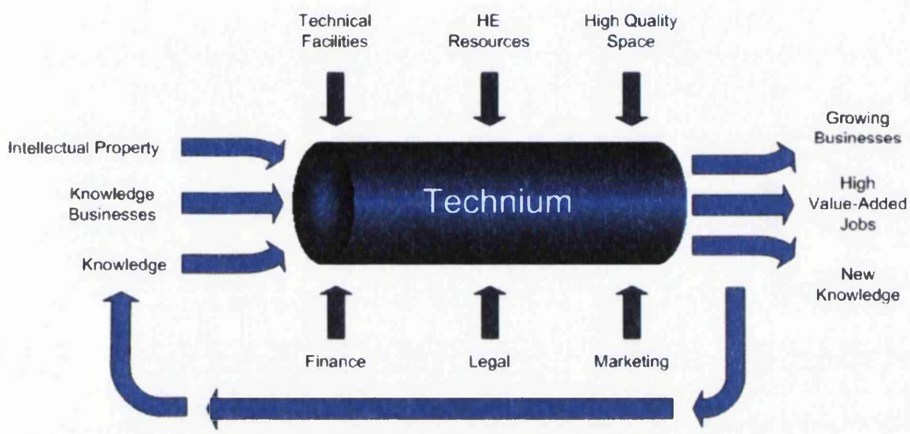


Fig. 5.1 - The Technium Concept
(Used courtesy of the University of Wales Swansea)

Technium has a range of criteria to act as guidelines in the selection of companies who join the initiative. This is done to maintain its focus on 'Knowledge Businesses'. These criteria state that companies should;

- Be innovative, high growth potential companies
- Be based in a High-tech or Knowledge-based sector
- Be exploiting IPR
- Be engaged in Research and Development
- Already have, or wish to develop, academic links
- Have in place a capable management team
- Have a sustainable financial status
- Have considered the period they wish to remain in Technium
- Have an established and credible business/marketing plan

The Centres

Technium operates from a network of Centres, providing support to a range of sectors. The first Technium Centre to be developed was aimed at a broad cross-section of knowledge businesses, while subsequent centres have been developed offering support to specific sectors. This sectoral approach aims to support existing and developing regional clusters, including those identified in the DTI study of UK clusters, such as automotive, aerospace and biotechnology (DTI 2001). This study focuses on the centres in South West Wales, each of which is described later in this section.

The overarching concept is to nurture knowledge businesses in an environment with support for the whole process of innovation and business development including finance, legal and marketing support together with specialist technical facilities and other resources.

Incubation and Graduation

Once these businesses have been nurtured in Technium they are then assisted to 'graduate' and embed themselves in the region to continue their growth. The group of these Centres associated with the University of Wales Swansea are described in more detail in the following sections.

As presented in a working document by Swansea University, Technium in South West Wales is not a straightforward start-up incubator designed for spin-outs from the University. Rather, it takes on a broader mission that is reflected in the mission statement as being;

"To assist in the incubation and continued development of the Knowledge Economy in the region".

This mission is also supported by the other partners, including the WDA. The WDA Corporate Plan (WDA 2002) describes how Technium is an initiative that;

"*...promotes innovation and entrepreneurship, supports new and growing businesses and inward investment in key sectors, utilises and promotes ICT connectivity, and in many cases is a catalyst for regeneration...*"

While there are indeed many start-ups in the Centres, some of which originated in one form or another from the University, the Centres are home to a mix of companies including inward investors from a range of countries in various sectors.

The Welsh Assembly Government's Wales Spatial Plan (2005) states that the Technium network should be involved in generating and growing the Knowledge Economy in two ways.

First, it proposes that "the University, HE institutions and Technia collaborate to create the virtual "*University of South West Wales*", and secondly, sets out the aim that "*the University, FE colleges and Technia should embed the Knowledge Economy within the area*."

5.2 Technium and the University of Wales Swansea

Since the first Technium Centre was established at Swansea Docks in a partnership including the WDA and the University of Wales Swansea, other centres have been developed across Wales including at St Asaph and Bangor in the North to Aberystwyth and Pembroke Dock in the west along with others in Carmarthenshire and Neath Port Talbot. A group of these centres, and the focus of this study, have been developed with involvement from the University of Wales Swansea. These centres include:

- Technium Swansea
- Technium Digital
- Technium Sustainable Technologies
- Technium Performance Engineering
- Technium Pembrokeshire

The following sections provide a brief overview of these Centres.

5.2.1 Technium Swansea

Fig. 5.2 Technium Swansea

Technium Swansea comprises of an initial centre which opened in 2001 and grow-on space (that was imaginatively named Technium 2) which opened in 2003. These combine to provide 30 units for tenants and co-locate DEIN business support staff that provide services to these and other centres in the region. The grow-on space provides assistance for companies in the smaller units (of both Technium Swansea and other centres) to develop while remaining within the incubation infrastructure. Key industrial partners in the initiative include Agilent Technologies, Morgan Cole and PriceWaterHouseCoopers.

5.2.2 Technium Digital, Swansea University and Bridgend

Fig. 5.3 Technium Digital

Established in 2003 on the Swansea University campus and with a satellite operation at the SONY factory in Pencoed, Technium Digital co-locates University research, specialist laboratories and 13 incubator units. The SONY satellite centre offers further incubation capacity together with specialist facilities including test and measurement, product development and manufacturing. The Centre links closely with departments in the University including Electrical and Electronic Engineering, Research and Innovation and the newly formed Institute of Advanced Telecommunications. Key industrial partners include Sony, Mitel, Cisco, 3M and IBM.

5.2.3 Technium Sustainable Technologies

Fig. 5.4 Technium Sustainable Technologies

Technium Sustainable Technologies opened in 2005 and is designed to support a wide range of companies from sectors including recycling, sustainable energy, advanced materials etc. Based at the former BP site in Baglan, the Centre offers incubation units that are co-located with specialist research expertise that is supported by Schools and Departments of the Swansea University including Engineering, Business and Research and Innovation. Industrial partners include 3M, BP and GE.

The Welsh Assembly Government was one of the first to undertake sustainable development as a legal obligation. Technium Sustainable Technologies is therefore seen as set to play an important role in developing products and services to support this agenda.

5.2.4 Technium Performance Engineering

Fig. 5.5 Technium Performance Engineering

Recently completed in Dafen, Carmarthenshire, Technium Performance Engineering focuses upon the Automotive and Aerospace sectors. Housing 15 incubator units the Centre accommodates specialist facilities including a Product Lifecycle Management development facility and is supported by research expertise in the School of Engineering and the Department of Research and Innovation at Swansea University. Industrial partners include the British Automotive Racing Club, the Welsh Automotive Forum and IBM.

The role of the Centre is to develop the automotive and aerospace clusters in Wales. The automotive components sector in Wales accounts for employment of over 12,000 in the country while aerospace industries employ some 5,650 people (DTI 2001).

5.2.5 Technium Pembrokeshire

Fig. 5.6 Technium Pembrokeshire

The most recent addition to the network is situated at Cleddau Bridge Industrial Park and has a focus on support of the Energy sector in the region. Incubator units are complemented by grow-on space to help anchor growing businesses within the locality. The Centre works closely with departments of the University including close interaction with the Power Electronics Research Group of the Department of Electrical and Electronic Engineering and the Environmental Law Group of the School of Law.

The Pembrokeshire region is undergoing a significant amount of development, centred on the construction of new Liquefied Natural Gas (LNG) facilities and power stations. This will see the region become particularly strategically important in providing for the energy needs, not only for Wales but the UK as a whole. The Technium development at Pembroke Dock aims to harness opportunities related to the energy industry to provide economic sustainability once the initial construction phase benefits fade away.

5.2.6 Non-South West Technium Centres

Technium Centres have also been established in other areas of Wales. Technium CAST and Technium OpTIC in North Wales aim to support the development of the software technologies and opto-electronics sectors in the region. Both Centres are supported by the University of Wales Bangor, though are managed by a private sector services management firm, SERCO. Technium Aberystwyth, located on the west coast of Mid-Wales has been developed to support knowledge-based enterprise, including spin-outs from the University of Wales Aberystwyth. Aimed at predominantly smaller companies, the Centre offers a mixture of incubation units and hot-desk facilities. These Centres are not included in the scope of this study due to the geographical and structural differences of these Centres compared to those of the South West, along with availability of data and limited access to the resident companies.

5.3 Project Development, Management and Governance

5.3.1 Project Development

The rationale for each of the Centres can be traced back to the aims of the Objective One Programme and its strategic Priorities (notably Priority 2: Developing Innovation and the Knowledge-Based Economy) and the strategies of the Welsh Assembly Government. Meanwhile, the objectives and focus of each Centre and the process of project development that culminates in the individuals submitted to and approved by WEFO. This process involved appraisal of options and was performed in partnerships involving public, private and education sector stakeholders. Input was also solicited from independent experts, such as the scoping exercise for Technium Sustainable Technologies undertaken by Oakdene Hollins (Morley and Parker 2004).

Along with the Centres described earlier in section 5.2, plans were created for the development of a Media Technium in Gelli Aur and a Biotechnology Technium in the National Botanic Gardens of Wales. The Media Technium concept was developed as a partnership between the WDA and Hartham Park Plc (WAG 2003c). Unfortunately the project was never realised following problems faced by the private sector partners. This led to criticism from some observers claiming that a substantial sum of public money had been lost in the failed venture (Cooke and Clifton 2005), though the WDA was at the time working to reclaim the £434k invested in the venture (Western Mail 2003).

The 'BioTechnium' project has also faced difficulties, though has since flourished in a new guise. Located in the National Botanic Garden of Wales the Centre offers incubation space together with specialist laboratory facilities (CCC 2003) at a cost of £4.4m. Unfortunately, the BioTechnium was interlinked with the operations of the Garden and the project stalled when the latter went into financial distress (BBC 2002). However, despite these challenges use of the Centre has been taken up by a group of bio-science companies relocating to Wales from an existing base in England (WAG 2007c).

5.3.2 Governance and Management

While each of the Centres is has its own management team to oversee their day to day operations, the governance of the initiative is provided by the Technium South West Steering Group. Organisations represented in the group include;

- Welsh Assembly Government (formerly by the Welsh Development Agency)
- City and County of Swansea
- Neath Port Talbot County Borough Council
- Pembrokeshire County Council
- University of Wales Swansea
- BP
- Sony
- 3M

The Steering Group has evolved with the development of the initiative. For example the Neath Port Talbot and Pembrokeshire local authorities joined when Centres were developed within their regions.

Between the management layer of each individual Centre and the Steering Group exists an 'Executive Group' which is formed of the Centre managers. This Group was recently established to assist managers in sharing experience and practices and to ensure collaboration within the network. As companies within each Technium may rarely travel between centres this Group is intended to assist in identifying potential linkages via the managers.

5.4 Previous Study of Technium

5.4.1 Academic Observation of Technium

The fullest discussion of Technium, though in relation to solely to those Centres in the 'hinterland' of Swansea University is provided in Abbey et al. (2005). This paper provides an overview of the initiative in the South West Wales region, its linkages with Swansea University and its role within a 'Sub-regional' Innovation System. Furthermore it includes discussion of some misconceptions and factual errors that it observes in previous observations of the initiative by Cooke and Clifton (2005).

The discussion of Technium by Cooke and Cliftom centres around the claim that the initiative includes establishment of twenty centres at a cost of £260m, though as contested by Abbey et al. (2007), these figures '*bear little resemblance to reality*'. Indeed, as shown by Abbey et al. (2007), the investment made into the South West Wales Technium facilities totals £51m while the three other operational centres (Technium Aberystwyth, Technium OpTIC and Technium CAST) totals £86m . Furthermore, this is inconsistent with the message emanating at the time from WAG, pledging *'up to'* £150m to be invested in the Technium initiative across Wales (WAG 2003).

Regarding the number of Technium centres, these investments represent a total of 8 (even counting the Technium Digital satellite facility as Pencoed as a separate facility would only bring this to 9). The WDA Corporate Plan did discuss the possibility of 2 'Regional Techniums' in the South-east of Wales, but even if these had been taken forward it would not amount to the 20 described.

More recently Technium has been discussed in the review of the use of Objective One Funding in Wales conducted by Cardiff University and commissioned by BBC Wales (Bristow et al. 2007). The purpose of the study was to appraise the effectiveness of the use of Objective One funds to address the economic woes of the most challenged parts of Wales.

In the report Technium is discussed as a case study and data provided by WAG is used as the basis of the analysis. The authors have divided the cash investment by the number of jobs to provide a 'cost per job' figure of £189,000 per job (or £84,000 per job considering Objective One funding alone). However, this would appear rather simplistic in that costs are included for Centres which are not yet operational, namely Technium Pembrokeshire and Technium Performance

Engineering. Furthermore, the jobs total of 439 employees contradicts the figure quoted by the BBC of 500 (BBC 2007), which as will be shown later is closer to the correct figure. The report does though recognise that the quality of jobs created is worthy of further investigation.

The discussion concludes in acknowledging that Technium is a long-term initiative and the results will take some time to be realised, though "*will be worthy of closer scrutiny*". Hopefully this thesis will serve as a start in such endeavour.

The contradiction, inaccuracies and requests for additional research would therefore suggest that further academic study of the initiative is required.

5.4.2 Other Observation of Technium

Non-academic discussion of Technium has been undertaken by various organisations including European funded projects such as the Cyfenter research programme, incubation associations including UKBI and other research bodies such as Science Alliance. A range of these studies are described below

UKBI

During 2006 UKBI undertook a review of business incubation in Wales which included certain Technium Centres (UKBI 2006). The purpose of the study was to benchmark the operations of Welsh incubation centres against the best practice described in the National Business Incubation Framework (NBIF). This examined aspects of operation including strategies for selection of tenant companies and support of their graduation from incubation

The report acknowledged that most of the centres in Wales are relatively young and therefore focused on the processes that had been put in place to assess the 'foundations' of business incubation. Reports were created for each centre in a manner much like the 'Personalized Report Card' provided to incubators in the 2003 NBIA survey (NBIA 2003).

The South West Technium Centres included in the study were Technium Swansea and Technium Digital. At the time of the study Technium Sustainable Technologies had only just been completed, while Technium Performance Engineering and Technium Pembrokeshire were still under construction. Other Technium Centres included were Technium OpTIC, Technium CAST and Technium Aberystwyth in North and Mid Wales.

The study provided its overall findings in an anonymised manner providing the range of results obtained by the group of incubators. It found that just over half of the incubators surveyed were operations in line with 'most or much' of 'good practice'. The rest were deemed to adhere to 'some' good practice, though two were regarded as 'below average'.

The provision of the findings in such a manner does not help understand how well the Technium Centres specifically are performing. However, the study does make some specific observations regarding the Centres involved in the initiative. These include recognition of positive aspects including strong academic links, though also noting the level of support available internally is not always as good as seen elsewhere. It should though be noted that these observations are in regard of a set of Centres, which include Centres outside of the scope of this study, and which does not include more recently established Centres within the scope of the is study.

Cyfenter

The Cyfenter Research Programme and its successor, Cyfenter II, were established as a partnership to investigate the business and entrepreneurship support in Wales with particular regard to minority groups (Cyfenter 2007). The Programme examined various aspects of business and enterprise support available in Wales including business mentoring and business incubation.

The Business Incubation research conducted by the Programme (Cyfenter 2004) provided a baseline of incubation facilities in Wales. However, as with the UKBI study described earlier it predated much of the development of the Technium initiative, including only Technium Swansea and Technium Digital in the South West of Wales.

The study aimed to establish an understanding of the sectors supported, support available and accessibility of facilities. It also included specific analysis of representation within incubators of 'Under Represented' groups including women, ethnic minorities and the disabled.

In its findings the study recognises that incubation in Wales is undergoing much change and development (it was undertaken during the main roll-out of the Technium initiative). The study found that the two Technium centres examined were easily accessible along with good representation of under represented groups, particularly young people and Welsh speakers.

Science Alliance International Business Incubation Competition

The Annual Science Alliance Business incubation Competition receives entries from around the globe and examines incubator performance including six award categories (CSES 2006);

- Return on Public Investment
- Self Sustainability
- Fastest Growth
- Most Promising New Incubator
- Good Practice
- Overall 'Best Science Based Incubator' Award

The competition forms part of the annual Science Alliance conference and is supported by the Centre for Strategy and Evaluation Services (CSES). To participate in the competition incubators completed an on-line questionnaire with information regarding;

- Operational costs and funding sources
- Growth and profitability of companies in the incubator
- Operational issues such as rental costs and support available
- Client views on services provided

Technium Swansea and Technium OpTIC both entered the fifth annual competition held in 2006 amongst a group of fifty international entries in the 'established' and 'new' incubator categories respectively.

As the information provided to the competition is confidential a detailed breakdown of performances is not publicly available. However, the top performances in each category are published along with the overall category winners. Technium Swansea performed well coming ninth overall in the 'Best Science Based Incubator' award and gaining sixth place in 'Return on Public Investment'. Figures for the latter and methodology of calculation were not published. However, a conference call was held with Mr Sander van der Wal of Science Alliance, one of the competition organisers, who kindly provided a description of Technium's comparative performance in a bowdlerised manner that did not breach the confidentiality of other entrants (Science Alliance 2007).

Taking into account only operational costs between 2003-06 (which postdates the construction phase and associated capital costs) the study evaluated the performance of Technium Swansea.

The 'cost per job created' in Technium Swansea was calculated as being ~ €10,000 (£7,500) within a range of ~ €4,100 - €30,000 (£3,075 - £22,250). However, Mr van der Wal stressed how care must be taken in considering such 'cost per job' figures as they often lost context such as types of job created, the sector they are in, the challenges faced in the particular region and other factors.

While the study provides an encouraging view of Technium Swansea, and in an international context of performance, it does not include analysis of the other Centres and its operation within the network.

6. Economic Impact of Technium

6.1 Overview

As described in the Chapter 5, Technium has been created as an initiative to catalyse the economic development of South West Wales through supporting the growth of the Knowledge Economy in the region. While the most meaningful benefits of Technium are envisaged as being returned in the future, via clusters of businesses that will have graduated into the community, there exists much interest in the economic impact which the initiative has already created. Bristow et al. (2007) for example, discuss the jobs created by the initiative, while Cooke and Clifton (2005) discuss the creation of new enterprise in the region.

This Chapter aims to provide a perspective of the economic returns to South West Wales *during its establishment of the initiative*, through development of an evaluation framework that examines a range of impacts. The author would like to acknowledge the guidance and support of the Institute for Policy and Economic Development in the development of this framework as well as that provided by his supervisor.

While this analysis does not (and cannot due to limitations of data and resource) investigate every economic impact of the initiative, it aims to capture the primary benefits including those realised during the construction phase, employment impacts during operation of the Centres, and appraisal of other returns to the region. The framework has been developed in line with the relevant guidance and practice from UK and EU governments, and each component of the analysis is underpinned by appropriate methodologies as described in the following sections. Wherever specific values have been used, they have been calculated from surveys (including those described in Chapter 7), and drawn from appropriate sources, such as the Welsh Economy Research Unit (WERU) and StatsWales; the official statistics service of WAG.

The following sections describe the development, application and findings of the assessment as follows:

- **6.1** The Role of Evaluation, and Economic Impact Assessment Tools and Practices
- **6.2** Presentation of the Framework and Impacts assessed
- **6.3** Findings of the Assessment
- **6.4** Discussion of the combined impacts

6.1.1 The Role of Evaluation

Evaluation of projects and initiatives is important for a number of reasons;

- Understanding whether objectives have been achieved
- Demonstrating whether investment of resources was made appropriately
- Learning how to improve in future similar efforts
- Comparison with effectiveness of efforts
- Helping develop and spread best practices

Often evaluation is also a legal or regulatory requirement (HM Treasury 2003, EU 2002).

Best practice does not consider evaluation as a stand-alone concept, but rather as a phase in an ongoing cycle. This is clearly demonstrated in the 'ROAMEF' cycle presented in the appraisal and evaluation guidance provided by the UK Government (HM Treasury 2003). ROAMEF is an acronym for the stages of the cycle, namely; Rationale, Objectives, Appraisal, Monitoring, Evaluation and Feedback, as shown in Fig.6.1 below;

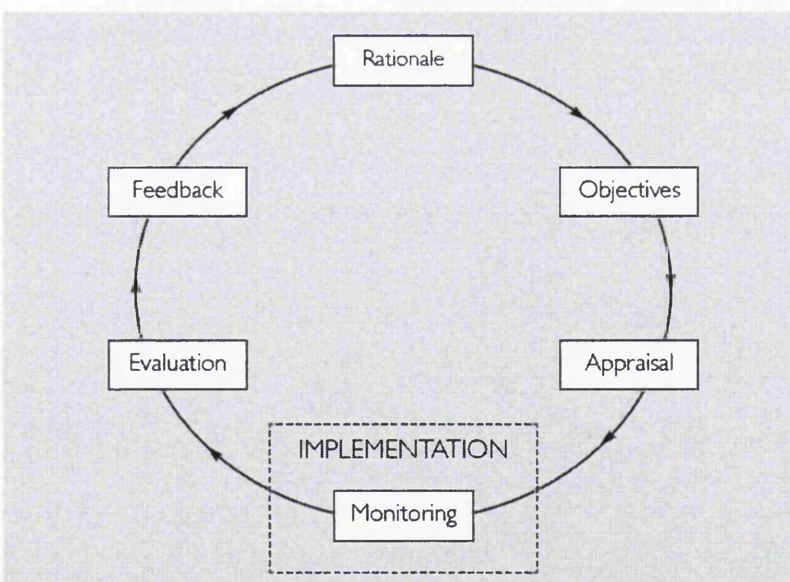


Fig. 6.1 'ROAMEF' Cycle (HM Treasury 2003)

This cycle demonstrates the interdependencies of stages. Effective monitoring of a project is required to provide information for an evaluation that is made against the objectives which were developed from the rationale. The same is also true at the outset of a project where, for example, a clear rationale is required to develop meaningful objectives.

Despite the perhaps apparent suggestion of the diagram in Fig.6.1, evaluation is not necessarily confined to post-implementation. The cycle can be ongoing and evaluation can be 'ex-ante' or 'ex-post' looking back at what has been achieved. Ex-ante evaluation can help to inform whether objectives are likely to be met, providing feedback on project or programme performance before all resources are expended. Where projects underway are seen to be succeeding they can be expanded or replicated to provide greater benefits, or if problems exist, changes can be made to correct the situation. Both types of evaluation can be applied to an initiative. A prime example is the evaluation of the use of Structural Funds in the Objective One Programme for West Wales and the Valleys. A Mid-term review (WEFO 2003) provided ex-ante evaluation of the Programme while a formal ex-post evaluation will also be completed.

Evaluations typically focus on the impacts of investments in relation to the size of the investment. Cost-Benefit analysis can help demonstrate whether an investment would provide a sufficient rate of return to make it worthwhile, while Cost-Effectiveness analysis can help to compare the net benefits of competing projects and different project options.

Guidance

To aid evaluation, guidance is provided by governments (HM Treasury 2003, EU 2002, EU 2003b) and other bodies (WEFO 2005b) to evaluate the impact of projects. Frameworks such as PRINCE2 (Projects In Controlled Environments 2) (OGC 2005) can assist by integrating the requirements of the cycle with project management activities. Developed by the UK Office of Government Commerce, PRINCE2 effectively integrates each of the stages of the ROAMEF cycle from Rationale to Feedback.

Official guidance for evaluation of public Programmes and Projects in the UK (including Wales) is provided by the HM Treasury Green Book (HM Treasury 2003). This aims to provide best practice for appraisal and evaluation of projects of all types and sizes, covering their economic, financial, social and environmental aspects. The Green Book is accompanied by 'The Orange Book' (HM Treasury 2004), which supports the management of risk in the public sector.

The European Union also offers guidance relating specifically to economic development initiatives in 'The Guide: The Evaluation of Socio-Economic Development' (EU 2003b). This guidance provides an in-depth resource for the planning and undertaking of evaluations. Although it is aimed primarily at the programme level (i.e. in consideration of multiple interrelated projects), it provides a useful resource for all types of evaluation.

Another European Commission document, 'Guide to cost-benefit analysis of investment projects' (EU 2002) provides specific guidance on a range of interventions including investments as diverse as ports and airports, museums and archaeological parks. In relation to 'Industrial Estates and technological parks', it is suggested that such interventions are evaluated with a time horizon of at least 20 years and that the wider social benefits, such as improved entrepreneurial skills are included. This is consistent with the vision of Technium (and the theory of cluster development), that the most significant benefits would be reaped in the long-term.

Evaluations can employ a variety of techniques and practices. The choice and application of techniques can depend upon the scope of the study, the availability and comparability of data etc. Approaches to evaluation are often characterised as being quantitative, qualitative or a mixture thereof. This is discussed in more detail in section 6.1.3 (for economic impact evaluation) and Chapter 7 (for other evaluations).

Evaluation of European Structural Fund Projects in Wales

The evaluation of European Structural Funds Programmes in Wales is integral to their management. This feeds down to the project level, for Programme evaluation is an agglomeration of numerous project impacts and therefore requires input relating to individual project performances. To achieve this, projects are subject to ongoing monitoring of achievements and outputs which are communicated to WEFO. Verification and request for evidence to justify these reports can be requested by various parties involved in the European Funding including the European Commission, the European Court of Auditors and WEFO themselves. WEFO often carry out inspection of projects to verify performance in what are termed 'Article 4 Visits', referring to an article of the associated EU Regulation, No. 438/2001 (EU 2001).

6.1.2 Rationale, Objectives and Appraisal – Technium

The cycle presented in Fig.6.1 (p.110) implies that investigation of Technium and its impact within the region begins with an understanding of its rationale and appraisal. This has already been treated in detail in Chapter 5, though can be summarised as being to (Technium 1999, WAG 2004c);

- Establish an integrated knowledge-based business support infrastructure
- Embed the Knowledge Economy within the region
- Support innovation amongst companies within the region
- Retain, attract and support the development of higher-level skills within the region
- Attract inward knowledge-based investment to the region

It is against these aims that Technium will be evaluated using the methodology described in section 6.2.

6.1.3 Economic Impact Analyses and Techniques

Economic impact assessments analyse the cumulative effects of expenditure through the economy and are often associated with understanding the effects of exogenous changes such as public or private investment in a region (Lewis 1988), though can also provide understanding of the importance of existing activity. Such impact assessments provide useful tools in understanding the benefits or challenges of change; both positive and negative.

They are often used by organisations to highlight the importance of employers in the region. Examples of this include work done by the University of Strathclyde for Universities UK to demonstrate the importance of the UK Higher Education sector (UUK 2006) and work done by Cardiff University investigating the impact of their institution upon the region (Cooke 1997). Impact assessments have been performed for all manner of institutions and issues, as diverse as Portsmouth Naval Base (Grainger et al. 2007) and the introduction of a new version of internet addressing (US Gov 2005). However, impact analyses are not always about estimating benefits or quantifying potential extra returns. They are often used to help understand and plan for negative changes such as plant closures and other disinvestments. Examples of this include studies examining the closure of the BP Llandarcy facility in Swansea (Barney et al. 2000) and the collapse of MG Rover (Regeneris 2005).

The examples of negative impacts highlight how the loss of employment can have significant knock-on effects in the wider economy, as supply chains suffer the loss of custom, local shops benefit from less disposable income etc. The same logic holds for positive investment and increase in expenditure, whereby increased employment and wages result in benefits to the wider economy. People employed directly by the investment will benefit, but so do those (such as retailers) with whom they spend their wages. This 'amplified effect' of investment is called the '*multiplier*' (Samuelson 1964). This extra effect is not only manifested monetarily but also in terms of employment, for more disposable income equals more income for factories shops etc. and more staff to deal with the extra custom. Not all of the effect of the multiplier will be kept within the region as expenditure on imported goods and services will lead to leakage of part of the benefits.

Economic impact analyses add the multiplier effect, to the multiplicand (i.e. the initial investment) to determine the overall impact (Lewis 1988). The challenge exists in determining the appropriate value of both the multiplier and the multiplicand. While the multiplicand may appear straightforward, consideration is required as to what parts of the investment are applicable.

With regard to the multiplier, its value will depend upon a range of factors including the industry sector(s) involved, the propensity of individuals to spend or save their income, taxation and the extent and structure of the region within which the impacts are being considered. Approaches used in determining multiplier values are;

Keynesian income and employment multipliers

The development of Keynesian multipliers relies on the assumption that there exist unemployed resources in the economy. An injection of income results in the recipients spending some of this money, thereby supporting wider employment and enterprise.

The basic equation for the multiplier is given by (Lewis 1988);

$$Kr = \frac{1}{1-c\,(1-td-u)(1-m)(1-ti)}$$

where; Kr is the Keynesian income multiplier for GDP
c is the marginal propensity to spend disposable income
td is the marginal propensity to pay direct taxation
u is the marginal transfer benefit/income ratio
m is the marginal propensity to spend on imports
ti is the marginal propensity to pay indirect tax on goods and services

Note that imports could include foreign holidays, Japanese televisions etc., though not the local television salesman's commission or the profit made by the local travel agent.

This approach of developing multipliers is applied in studies such as the work of Cooke (Cooke 1997) in evaluating the economic impact of Cardiff University.

Economic-base multipliers

Economic base multipliers are developed from the idea that economies are made up of 'basic' and 'non-basic' sectors. The basic sector is entirely dependent upon external conditions while the non-basic is made up of businesses that are largely dependent upon internal market conditions within the economy being considered. Economic base theory suggests that an economy is strengthened by growth in this basic, export-oriented sector, which creates further jobs in the non-basic sector.

Underpinning the concept is the assumption that increasing exports is the primary driver to increasing income and wealth of an economy, effectively bringing money 'into' the economy (Pleeter 1980). The theory suffers from some limitations similar to those of the Keynesian approach described above. For example, full employment in an economy could see increased demand for exports resulting in increased income, though no extra employment in the non-basic sector. In fact, if labour is limited, employees may move from non-basic to basic industries, causing employment in the former to contract. Furthermore, neither approach takes account of immigration, where new labour could move into an economy (Lewis 1988). Other issues include the assumption that the economy is in equilibrium at the start and neglect the benefits of import-substituting investments (Pleeter 1980). If an economy can manufacture its own goods or services to substitute for imports this can have a positive effect the same as increasing exports of something else.

Such limitations may be thought not to apply to our part of Wales where unemployment persists and the 'economically inactive' can provide further potential human resources. This is not though as clear cut as it may seem, for while 'labour' may exist, the skills and expertise required by the basic sector may not be readily available, as described in Chapter 3.

Input-Output Tables

First created by Wassily Leontief in 1936, Input-Output models provide great detail regarding the transactions within economies between industries and sectors. This allows an understanding of the flows and impacts of changes throughout the economy as a whole. For example, a project to build a new bridge would require steel, which would produce extra demand for steelworks, iron ore, transportation, engineers etc. The increased need for steel would result in more steelworkers being hired, more sandwiches being consumed and farms needing to provide more ingredients to go into sandwiches and so forth. These sales between firms are categorised as being 'intermediate' products.

Input-Output models capture these inter-industry linkages in the form of matrices associating the output of one industry as the input of another (or group of others). Development of the models is particularly information and resource intensive at the sub-national or regional level. Much of the data used in their development has to be sourced from national import-export records, which do not exist for smaller territories. For this reason, the approach is primarily used for large scale issues. Input-Output tables are heavily reliant upon relationships which are static, posing a challenge where there are dynamic or complex relationships between industries (Pleeter 1980).

In the case of Wales, Input-Output tables have been prepared by the Welsh Economy Research Group (WERU) at Cardiff University. The latest openly available version was last updated in 2000 (WERU 2004). These tables provide data on the linkages within the Welsh economy and employment and income multipliers that relate changes within a particular industry sector to their effect on the wider economy.

6.1.4 Investment now and Benefits later?

An important aspect to economic impact studies is differentiating between values of past, present and future benefits, and relating these to past, present and future investments. Inflation is obviously one factor that affects the '*value*' of money as investments made in the past equate to a larger sum of money in the present or future. A further factor is that of opportunity cost, whereby investing in one opportunity precludes gains being realised from investing the same resources in another opportunity. In equilibrium the opportunity cost of capital is equal to the social rate of time preference (which reflects the preference for a given sum of money now, rather than some time in the future).

To adjust for this time preference a discount factor is used to adjust real cash values of both investments and benefits depending on when they occur. Different guidance exists on what this rate should be and how it is applied (EU 2002). For example, previous guidance provided by the UK Government suggested applying an annual compound rate of 6% to adjust for both inflation and opportunity cost. However, guidance now suggests adjusting for inflation using appropriate price indexes and then applying a 3.5% discount rate to adjust for opportunity cost of capital (HM Treasury 2003). Using this technique investments and benefits can be converted to '*Present Values*' (PV). By subtracting costs (in Present Values) from the benefits (in Present Values) a Net Present Value (NPV) for the investment can be calculated. A positive NPV suggests that the investment would provide a return on investment, taking into account the timing of investment and benefits.

While the UK Government suggests that a 3.5% discount rate be applied to inflation adjusted figures, other organisations apply different practices and rates, such as those used by the following organisations and territories; World Bank – 10%, US Government – 7%, France – 8%. Furthermore, the rate used often varies between type of project. For example in Spain transport projects use a 6% rate, while those developing water infrastructure use a 4% rate (EU 2002). Where investment is made upfront and returns come some time in the future a high discount rate means that only projects with a commensurately high return will present any potential benefit.

6.2 Developing the Impact Measurement Framework

6.2.1 Overview

Impacts

While it is well understood that the principal benefits of initiatives such as science parks and business incubators come some time after their inception, this analysis attempts to investigate the short-term impacts of Technium on the region and the Welsh economy. In this regard, this study examines the impact of the initiative during the period 2000-2008, which runs from the creation of the first Centre through to the end of the Objective One funding when all Centres will be fully operational.

This study aims to give an overview of certain impacts of the Technium initiative and attempts to quantify what has already been returned to the region and the economy of Wales, namely;

- Direct Employment Impact
- Indirect and Induced Employment and Wage Impact
- Centre Construction – Assets
- Centre Construction – Employment
- Rental Income

It is acknowledged though that this does not capture all benefits, such as support of entrepreneurship and development of a Regional Innovation System[13]. Furthermore, the greatest benefits to Wales will come from the successes of companies that graduate from the Technium centres, in a timescale beyond that considered in this analysis.

The Centres included in this study are those of South West Wales which fall within the Wales Spatial Plan Regions of: Swansea Bay – Waterfront and Western Valleys; and Pembrokeshire. The Centres are;

- Technium Swansea (Centres 1 and 2)
- Technium Digital (including the Centres at Swansea University and the satellite facility at the Pencoed Sony factory)
- Technium Sustainable Technologies
- Technium Performance Engineering
- Technium Pembrokeshire

[13] These impacts are the focus of following chapters

Models

Evaluation of impacts has to take account of external (i.e. non-market) costs and benefits and be sensitive to variation in factors such as multipliers used to assess indirect impacts, and assumptions concerning the valuation of assets. Here, three models are used to present a sensitivity analysis of the combined impacts.

A ***'conservative model'*** assumes very low multipliers and most modest valuation of assets. An ***'optimistic model'*** applies higher multiplier values and higher asset valuations. These models present the lower and upper extremes of the impact of Technium. Central estimates are provided by a ***'base model'*** that uses average values between the two extremes. This approach of presenting a combined sensitivity analysis with optimistic and pessimistic values for certain variables is suggested by the European Commission (EU 2002).

In all cases, costs and benefits are adjusted to current prices using the 3.5% discount factor prescribed in the Green Book guidance provided by HM Treasury (2003). All benefits and costs are expressed in terms of present values of the base year 2006; that is post-2006 benefits/costs are discounted; pre-2006 benefits are subjected to compounded interest equal to the discount rate. All prices are adjusted to 2006 equivalent using the GDP deflator (HM Treasury 2006), Appendix 4.

6.2.2 Direct Employment Impact

The primary impact of Technium is in the employment that it helps generate in the community. While some of these wages will leak beyond the region, much in the form of taxation (some part of which will return from UK Central Government to the Welsh Assembly Government) and otherwise, this is difficult to quantify without extensive surveying of individual employees. While this level of detail is not available to this study, previous surveys have calculated average remuneration amongst Technium companies. Therefore, for the purposes of this study, gross employment costs alone will be considered.

Furthermore, it should be noted that the future envisaged benefits of Technium are contained within companies that graduate from the centres. While future growth of these companies will be due to factors beyond their roots in Technium it can be argued that much of this growth would not have occurred within Wales had Technium not been there at their inception. For the purposes of this study employment in graduated companies is retained as a Technium benefit, but not any post-graduation employment growth.

6.2.3 Indirect and Induced Employment and Wage Impact

The direct employment within Technium and its companies is a clear benefit of the initiative and relatively straightforward to assess. However, these companies and their employees are but part of the wider community and economy in which they reside and upon which they make an impact, supporting further employment beyond the Centres through 'multiplier' effects. These impacts are more challenging to assess as these jobs are in a wide range of sectors and some expenditure inevitably permeates outside Wales.

Determining the magnitude of this multiplier effect depends on the types and sizes of expenditure made by individuals (e.g. how much is spent on local fish and chips, what groceries are bought and where, foreign holidays etc.), the region within which the multiplier is being considered (e.g. Wales, UK, EU) and other factors. As Technium is an initiative resulting from decisions made by Welsh public bodies (WDA and WAG), has benefited from Welsh central funding, and that aims to impact within Wales, this is the region considered in this analysis.

Determining an appropriate multiplier is challenging, as Technium is home to companies at different stages of their lifecycle in a wide range sectors that employ people at varying salaries in a variety of roles. Furthermore, the Centres are spread over a wide area which, coupled with the fact that the companies are growing and moving out into the community, makes the impact of Technium particularly dynamic.

For the purposes of this study three models are presented. These apply employment multipliers across values that represent the range of values for sectors of the Welsh economy derived from Input-Output tables constructed by the Welsh Economy Research Group (WERU). These range from 1.29 in the Textiles and Clothing sector to 2.32 for Oil and Chemicals (Munday et al. 1999). Some studies have suggested that multiplier effects for science parks and incubators are higher (Luger and Goldstein 1991, Wiggins and Gibson 2003), but some of these values were calculated during the technology boom at the beginning of the century and in different regions under dissimilar circumstances. Therefore for this analysis the more reserved range described below will be applied.

The 'base' model assumes a multiplier of 1.5, implying that each Technium job supports 0.5 further jobs in the community, which is representative of various sectors of the Welsh economy (see Appendix 4 employment multipliers). At the lower extreme, the 'conservative' model applies a multiplier of 1.25. The second 'optimistic' model assumes a multiplier of 1.75. These multipliers are Type II, meaning they capture the knock-on effects of spending within the community and within the supply chain, which are hereafter referred to by the technical description of 'indirect and induced' impacts.

6.2.4 Centre Construction – Assets

Technium is a long-term initiative which, it is hoped, will continue to deliver benefits for several decades. Quantification over such a period is fraught with uncertainty. As, an alternative, valuations are taken up to a time horizon of 2008, and future benefits are captured in terms of the value of assets at this date.

While the focus of the Technium initiative is to develop knowledge businesses in the region, it also delivers a set of valuable assets to the region; the Centres themselves. Though sale of the Centres is not the intention of the partners involved in the initiative, they are not a sunk cost but a clear asset that can continue to deliver benefits into the future. Furthermore, consideration of the residual value of a project as an inflow at its 'end' is a practice required by the European Commission in analysis of the cost-benefit of ERDF projects, including explicit reference to buildings. As Technium is a long-term initiative there is in-effect no project 'end'. Therefore for the purposes of this evaluation it is assumed that it is looking at the present values of an integrated Technium South West project that ends in 2008.

Valuation of commercial property is a complex art and much depends on the building usage, its location and other market factors etc. to determine an appropriate yield. As each of the Centres is located in an evolving environment and market with its own unique circumstances the consideration of 'base', 'conservative' and 'optimistic' models has been adopted.

The 'base' model assumes that the residual value of the Centres is 75% of their construction cost. The 'conservative' model values all Centres (including those in the SA1 area) at 50% of their construction cost, while the 'optimistic' model values the buildings at their full construction cost. In each case the value of the land was included at full market value, for it formed part of the match funding[14].

6.2.5 Centre Construction – Employment

Along with the value of the assets created by the initiative the construction phase also has an impact in creating and supporting jobs directly and indirectly in the community. While these impacts are fixed in duration they represent a significant return to the region. As well as quantifying labour used on site the study has also investigated the professional services aspects of the projects. Furthermore, as with consideration of the Technium company jobs, the construction phase also results in a multiplier effect (though also of limited duration).

This has been calculated in the same manner as for the company employment impacts, using 'base', 'conservative' and 'optimistic' models to present the impacts, applying multiplier values of 1.25, 1.5 and 1.75, respectively, to model indirect and induced impacts, as applied to the Technium companies' employment. As the jobs involved in the construction phase differ to those in Technium companies a separate average salary was calculated in assessing this phase of the project. Data for this part of the analysis were provided by the lead contractors for the Centres and from the project managers overseeing the construction for the lead sponsoring organisation.

[14] The validity of this approach to provide a valuation was discussed with the Director of the Welsh Assembly Government's Regional Property section in South West Wales and his team. He advised that only such a broad-brush could be practically be used for there exists potentially great variation in the value of the separate Centres.

6.2.6 Alternative Investment

Without having access to the options for other potential investments considered by WEFO, the Welsh Assembly Government and other partners responsible for selecting the Technium initiative, it is difficult to develop a base-line against which to reflect and contrast the performance of Technium. Typical 'cost per job' benchmarks are unsuitable for this type of comparison as the Technium job creation is designed to be dynamic and ongoing, while these figures are generally associated with investments resulting in one-off job creations. In the absence of any clearly defined alternative project, the discount rate is taken to represent the social opportunity cost of capital.

6.3 Evaluating the Impacts

As described in the previous sections this study examines the impacts of the Technium Centres of South West Wales in the period 1999-2008[15]. This timescale extends from the inception of the first Centre; Technium 1 through to the end of the Objective One spending on the initiative in 2008 when all Centres will be fully operational.

6.3.1 Data Collection

The first phase of the impact assessment consisted of collating data to perform the assessment. These data related to and were sourced as follows:

Costs – The costs associated with each Centre were collated from the Centre managers. These figures were verified through comparison with the original Objective One applications and associated project plans for each Centre. Future running cost projections were taken from the Centre managers and the business plan of the Technium South West Steering Group (Technium 2005). These were adjusted to current values (2006)[16] and the 3.5% Social Time Preference Rate (STPR) value used to adjust for opportunity cost of capital employed. Table 6.1 presents a breakdown of these costs together with the adjusted values used in the analysis[17].

Employment – During the Objective One project phase the employment within each Centre has been continuously tracked. This information, together with supplementary data provided by WAG for Centres no longer funded by Objective One[18] was verified against the data collected in the company survey described in Chapter7. Projections for future employment were provided by the Technium managers[19] and were in line with the aspirations of the business plan of the Technium South West Steering Group (Technium 2005). The employment within the Centres during the period is presented in Table 6.1 with a full breakdown by Centre over time provided in Appendix 6.

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[15] A pan-Wales study including the other Technium Centres in North and Mid Wales, using the same methodology has been developed by the author. It is available from the Institute of Policy and Economic Development at the University of Texas at El Paso, iped.utep.edu

[16] This was done using the GDP deflators provided by the UK Government HM Treasury as included in Appendix 4

[17] A full breakdown of investment is provided in Appendix 6

[18] Technium Digital and the first phase of Technium Swansea (Technium 1) are no longer funded by Objective One, though employment in the Centres continues to be monitored

[19] The Technium managers and the Technium South West Steering Group described confidentially to the author the opportunities in the pipeline which make them believe the projections provided offer a relatively conservative perspective of the future

Construction – Project managers from DEIN Property section and Swansea University's Estates department were interviewed to ascertain the breakdown of costs, employment and timescales involved in the construction of each of the Centres[20]. A breakdown is included in Appendix 6.

Rental Income – A detailed breakdown of rental income by Centre was not available as such information has not been captured during the period 2000-2005. However, following the merger of the WDA with WAG, new accounting procedures have been adopted allowing figures for the last financial year to be collated. The managers of each Centre stated that rental charges had developed in line with inflation, though were unable to link past income to past occupancy, for tenant companies had taken up occupancy at a variety of rates. However, it was possible to use the 2006 'snapshot' of rental to calculate a 'per employee' rental income that was then extrapolated backwards and forwards allowing calculation of past and projection of future rental incomes. Calculations, together with a breakdown of rental income, are presented in Appendix 6.

[20] The author would like to extend particular thanks to Mr Ron Slater, manager of the DEIN South West Property Section Office who very kindly provided data and assisted in explaining the WAG role in property development in Wales

Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**Total**
Capital (£'000s)	285	1,924	0	4,857	3,687	11,750	9,927	4,427	0	0	**36,856**
Revenue (£'000s)	0	415,500	462	861	1,297	3,319	2,672	2,050,	1,266	1,305	**13,647**
Total (£'000s)	**285**	**2,340**	**462**	**5,718**	**4,984**	**15,069**	**12,600**	**6,477**	**1,266**	**1,305**	**50,503**
Total Present Values (2006) (£'000s)	**427**	**3,318**	**624**	**7,296**	**5,957**	**16,901**	**13,288**	**6,477**	**1,191**	**1,156**	**56,634**

Table 6.1: Technium Investment

Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Technium Company Jobs	0	0	79	117	166	199	299	450	600
Technium Support Jobs	4	8	10	12	18	22	22	22	22
Total Jobs	**4**	**8**	**89**	**129**	**184**	**221**	**321**	**472**	**622**

Table 6.2: Technium Employment

The following sections present the findings of the impacts studied, namely:

- Direct Employment Impact
- Indirect and Induced Employment Impact
- Centre Construction – Assets
- Centre Construction – Employment Impact
- Rental Income
- Combined Impact including discussion

6.3.2 Direct Employment Impact

Two of the Centres, Performance Engineering and Pembrokeshire, have only just been completed (in late summer and autumn 2006 respectively) and another, Sustainable Technologies, is still at its outset, having only been operational for eight months. However, there already exists in the established and operational centres a significant amount of employment. At the end of 2006 this stood at 321 jobs of which 299 are in resident companies and 22 in support roles including business support, technology support, facilities management, receptionists etc. (not counting graduated companies).

As all of the Centres in South West Wales become operational, it is projected that employment will continue to increase, reaching a total of 622 jobs in 2008 as shown in Fig.6.2 and Appendix 6.

While Technium itself (and most of its companies) are in their infancy, there are already instances of companies moving on from incubation into the wider community. To date, 20 jobs have moved out of the Centres into the region and this figure is set to grow with a number of companies poised to graduate during the next few years.

Surveys of Technium[21] Centres have allowed average salaries within Technium companies and their support to be base-lined during 2003 and 2006. Using these figures average salaries have been interpolated for years 2004 and 2005, and extrapolated for years before 2003 and after 2006. Using these figures with the historic and projected employment performances it can be shown that at the end of 2006 Technium has had a direct wage impact of £30.5million, which is set to rise to £57.2million by 2008 (as shown in Fig.6.3).

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[21] These surveys which were undertaken by the author and also form part of this thesis are described in Chapter 7

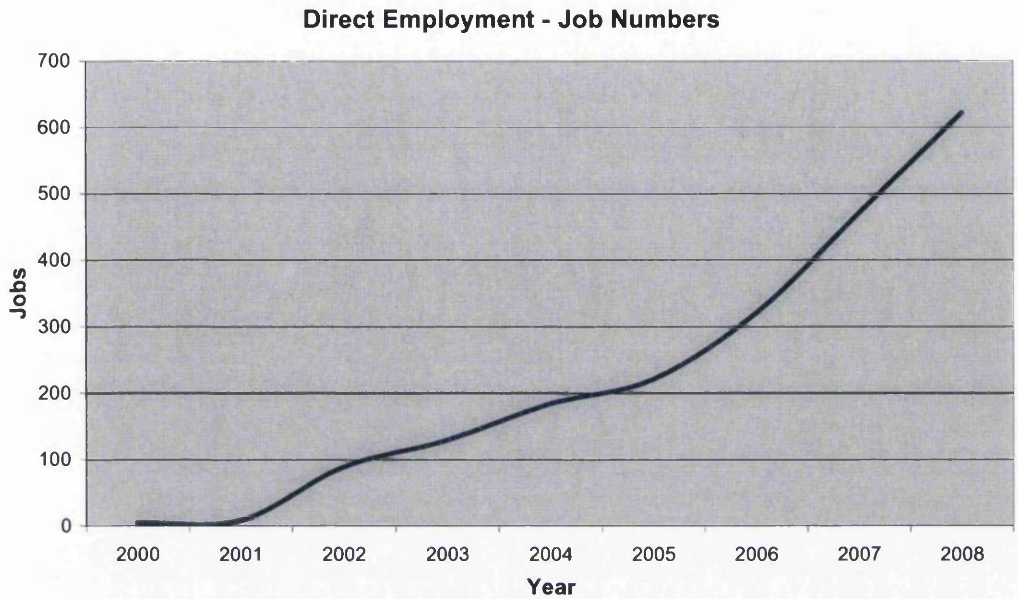

Fig.6.2 Direct Employment – Number of Jobs in Technium Centres

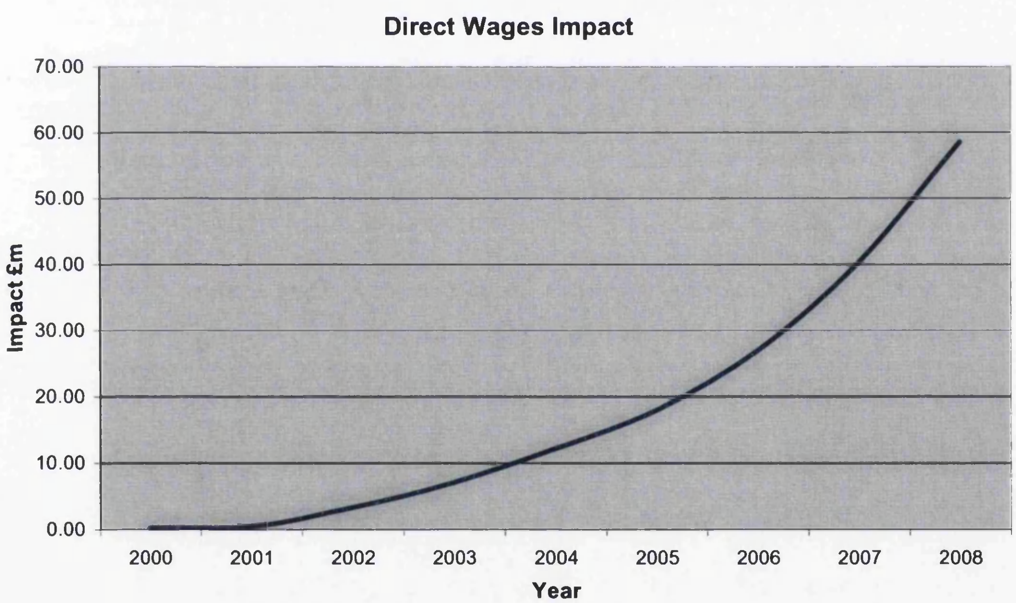

Fig. 6.3 Direct Employment Economic Impact

6.3.3 Indirect and Induced Employment and Wage Impact

As described in the methodology section, the indirect and induced impacts of Technium have been appraised using 'conservative', 'optimistic' and 'base' models. This indirect employment results not only from employment in the Centres themselves, but also from jobs graduating into the community, which are not themselves captured by the multiplier[22].

The 'base' model (1.5 multiplier) suggests that at the end of 2006 a further 171 jobs are supported in the community. This would be projected to grow to 366 by 2008. The corresponding figures for the conservative model (multiplier 1.25) are 85 and 184; and for the 'optimistic' model (multiplier 1.75), they are 256 and 549 (see Fig. 6.4). The value of these jobs was calculated[23] as £5m by 2006 and £10m by 2008 for the base model; £3m and £5m for the conservative model; and £8m and £16m for the optimistic model. The impacts are presented in Figs. 6.4 and 6.5 and Appendices 6, 7 and 8.

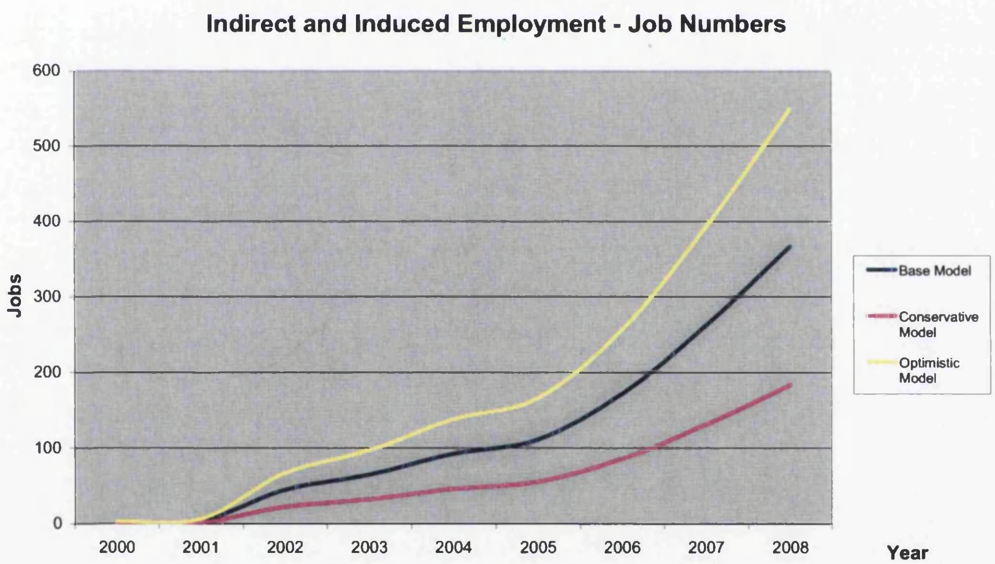

Fig. 6.4 Indirect and Induced Employment – Job Numbers[24]

[22] Any effect of Technium in sustaining jobs in graduated companies is neglected after the third year post-graduation. For this analysis no company fits this criterion, therefore it has effect
[23] These calculations are based on average salary values within the Welsh economy for the years considered during the analysis. These were acquired from StatsWales, statswales.wales.gov.uk, 2006. Projected average salaries for future years were calculated by adjusting for inflation using values in Appendix 6
[24] Due to scale early impacts are more clearly presented in Appendix 6

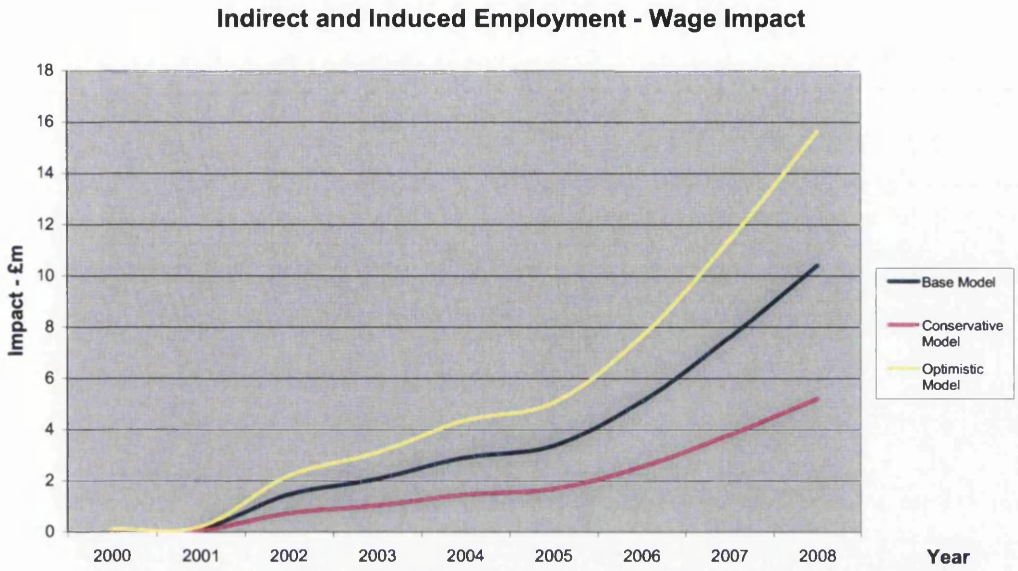

Fig. 6.5 Indirect and Induced Employment – Wage Impact[25]

6.3.4 Centre Construction – Assets

The construction of the Centres created 124,000sq.ft. of incubation space[26] across South Wales (Technium 2005). As described in the methodology, this analysis bases valuation of the Centres on their construction costs, which are presented in Table 6.3.

Centre	Completion Date	Investment
Technium 1 (Phase 1: Technium Swansea)	April 2001	£2.2m
Technium Digital (Swansea University)	April 2003	£4.6m
Technium 2 (Phase 2: Technium Swansea)	June 2003	£4m
Technium Digital (Sony Pencoed satellite)	July 2005	£0.5m[27]
Technium Sustainable Technologies	October 2005	£6.6m
Technium Performance Engineering	October 2006	£5.2m
Technium Pembrokeshire	November 2006	£10.5m[28]

Table: 6.3 Technium Centre Construction Costs

[25] Due to scale early impacts are more clearly presented in Appendix 6
[26] This includes 25,000sq.ft. of grow-on space at Technium Pembrokeshire
[27] As the Technium Digital satellite facility is part of the Sony Pencoed plant, its costs have been included, though it is not included as an asset
[28] This cost includes the grow-on space at Technium Pembrokeshire

The 'base' model implies a value of £28.5m value to the Centres. In the case of the 'conservative' model the total value is £19million. The 'optimistic' model on the other hand yields an asset value of £38million (as presented in Fig.6.6)[29], which is more than either the non-Objective One investment of £31.6million or the Objective One investment of £22.5million.

However, the Technium initiative is not a European Union subsidized property development scheme and these assets are perhaps best considered as offsets against costs rather than themselves as returns.

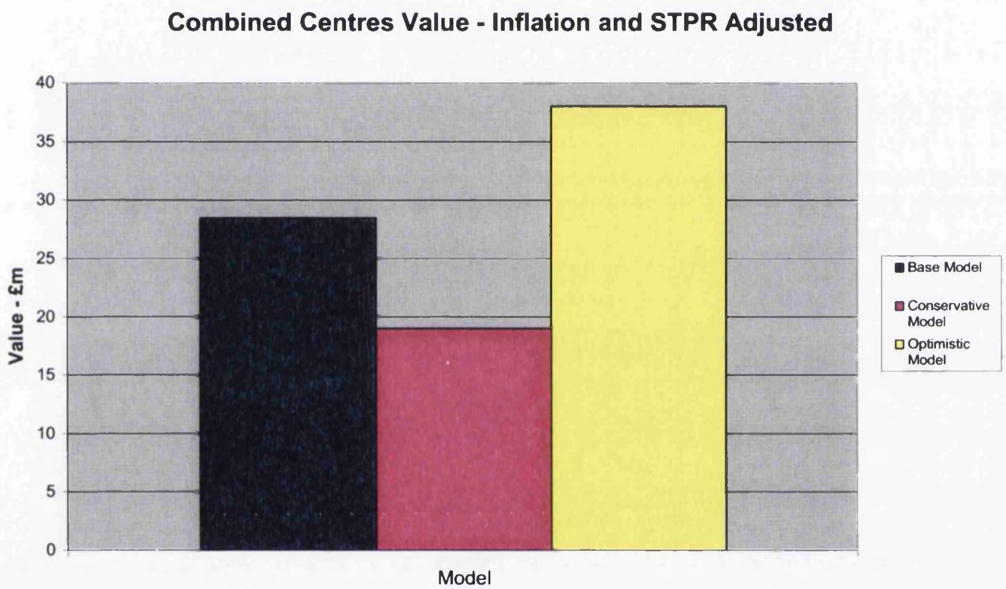

Fig. 6.6 Combined Centres Values

[29] These figures have been adjusted for inflation and the STPR discount factor for inclusion with the other impacts

6.3.5 Centre Construction – Employment

A high proportion of labour used (90%) in construction of the Centres was sourced locally. This was found to be the case for both the labour and professional services used in the constructions. While the number of people working on any project varied as it progressed, there were on average 31.72 people, of whom 28.55 were local to a centre[30].

The approach of using 'base', 'conservative' and 'optimistic' models as applied in the evaluation of Technium company employment, was used in considering the impact of the construction phase. This assumed the same multipliers of 1.25, 1.5 and 1.75. In each model the impact was only quantified for the 'local' workers, assuming that any other impact was made outside of Wales. The 'base' multiplier of 1.5 is close to that of the construction industry as a whole presented in the Appendix 5, where the employment multiplier =1.43 and GDP multiplier =1.70.

Average wages from the construction projects, provided by the lead contractors and project managers, were used to quantify both direct and indirect and induced impacts of the construction phase. This was analysed in the same manner as applied to calculate the direct, and indirect and induced employment impacts for the Technium companies. For the 'base', 'conservative' and 'optimistic' models this culminates in impacts of £19.7m, £16.4m and £23m, respectively. Presented in Fig.6.7 are the employment and wage impacts, direct, indirect and induced of the construction phase in each year of the construction of the Centres according to the 'base', 'conservative' and 'optimistic' models[31].

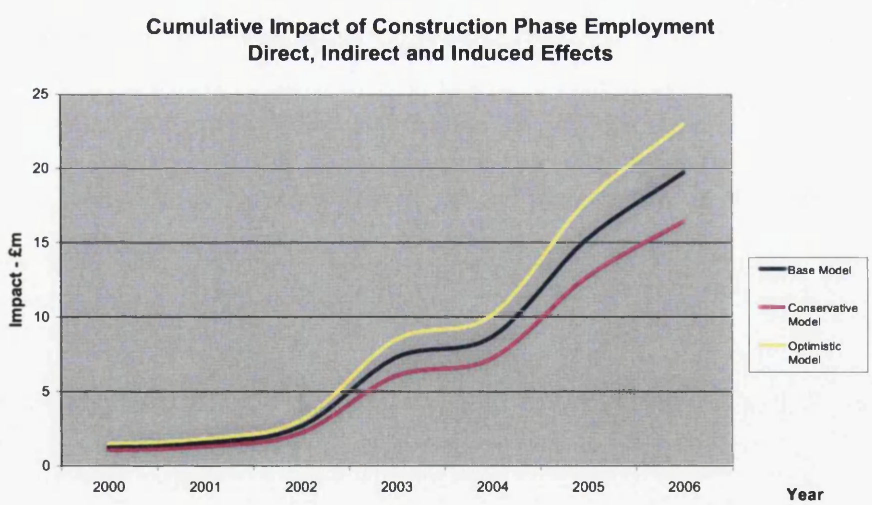

Fig. 6.7 Cumulative Impact of Construction Phase

[30] A breakdown of Construction phase employment and expenditure is included in Appendix 6
[31] Calculations are included as a spreadsheet in Appendices 6, 7 and 8

6.3.6 Rental Income

As described in section 6.3.1, data were not available providing a breakdown of rental income by Centre by year. However, data for 2006 were available, providing a benchmark of rental income. During the year £921,599 was returned to Technium[32] across Wales from companies supporting 548 jobs. This equates to £1,681.75 per employee per annum. A per employee value was calculated as future occupancy projections do not exist for number of companies, but only for employment. Adjusting this value by inflation and for STPR allows rental incomes for each year to be calculated in respect of the number of employees[33] as presented in Table: 6.4 and Fig.6.8. Full workings are included in Appendix 6.

Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Rent per Job	£1,457	£1,478	£1,513	£1,560	£1,606	£1,650	£1,682	£1,727	£1,774
Jobs	4	8	89	129	184	221	321	472	622
Rental Income[34]	**£8,267**	**£15,983**	**£171,828**	**£240,528**	**£331,482**	**£384,675**	**£539,842**	**£766,797**	**£977,009**

Table: 6.4 Rental Income by year

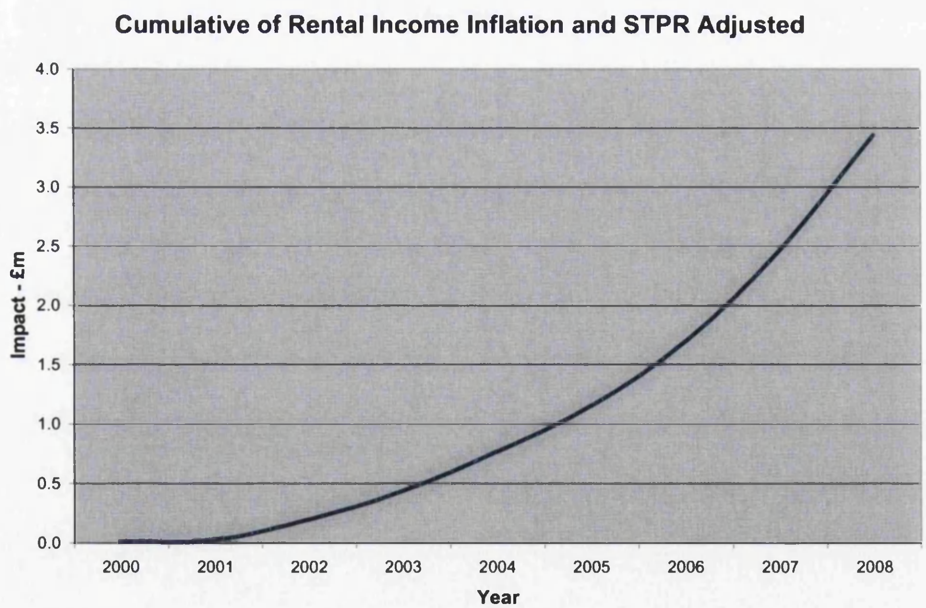

Fig. 6.8 Cumulative value of Rental Income

[32] This data refers to the pan-Wales Technium network. It has been used as it provides a wider sample upon which to base the calculations of the benchmark
[33] These calculations apply solely to the Technium South West Centres
[34] Inflation and STPR Adjusted

6.4 Combined Impact and Discussion

Previous sections have described individual benefits arising in three models. Combining the benefits of these impacts provides a clearer picture to compare against the investment made (as presented in Table: 6.1). It can be seen for each of the scenarios, the combined benefits are of significantly greater value than the investment made. Even for the most conservative model, the employment impact alone is significantly more than the total investment. This analysis also highlights the importance of considering impacts often overlooked in other studies (Cooke and Clifton 2005, Bristow et al. 2007). For example, in the case of the base model the impact of rental income during the period and value of assets is worth more than half the investment.

Impact (Present Values) / **Model**	**Base** (£,000s)	**Conservative** (£,000s)	**Optimistic** (£,000s)
Company Employment and Wages (Direct, Indirect and Induced)	£97,948	£81,418	£114,477
Construction Phase Employment and Wages (Direct, Indirect and Induced)	£19,689	£16,408	£22,971
Residual Assets (Centre Values)	£28,541	£19,027	£38,055
Rental Income	£3,436	£3,436	£3,436
Costs (Present Values)	£56,634	£56,634	£56,634
Net Present Value (NPV)	**£92,980**	**£63,655**	**£122,305**
Benefit/Cost (B/C) Ratio	**2.64**	**2.124**	**3.16**

Table: 6.5 Combined Costs and Impacts by Model

The conservative and optimistic models provide a sensitivity analysis of the impact assessment, and even considering the more pessimistic of these two cases, it can be seen that Technium has provided a considerable return on investment. The Benefit/Cost (B/C) ratio puts these benefits in context of the level of investment made and demonstrates that in each model Technium has performed well, with a ratio no less than 2. Presenting a positive evaluation in the most conservative scenario (together with the other models) satisfies the guidance of the UK HM

Treasury (HM Treasury 2003) and EU Commission (EU 2002) for conducting such evaluations, and presents Technium as a worthwhile initiative.

Simply focusing upon the base model, which is intended to be most representative, Technium has made a significant impact. The combined impacts create a B/C ratio of 2.64, suggesting Technium has succeeded in delivering a significant economic impact to the region, supporting employment and providing the region with important economic development assets. Furthermore, as described at the start of this Chapter, the most meaningful benefits are to be realised in the future.

However, it should be remembered that this simply adds together the benefits but excludes other potentially important gains, such as innovation spillovers and support to development of an entrepreneurial culture[35]. On the other hand, the analysis includes all of the costs of the initiative. Understanding the further benefits would require further research such as valuation of the Technium companies themselves, measure of spill-over and other effects, which are beyond the scope and resources of this indicative study.

[35] Assessing further impacts of Technium is the focus of the following Chapter 7

7. Knowledge Enterprise in Technium

As described in Chapter 5, Technium aims to support the economic development of South West Wales by assisting in the growth of innovative knowledge-based companies. However, Technium exists in a wider community where many firms are already innovating and growing without its support. Therefore, for Technium to have an impact it must deliver benefits beyond what would be achieved in its absence. Such impacts may include development within Technium of;

- Enterprise which would not have been created otherwise, or at least not within the region
- Higher growth rates of companies assisted
- Higher levels of innovation amongst assisted companies
- A larger proportion of higher levels skills being retained and attracted to the region
- Greater company engagement with academia to exploit knowledge
- Greater intensity of networking and collaboration in terms of scope and geography

To assess whether such benefits exist, and to what extent, a survey was undertaken amongst Technium companies consisting of a questionnaire and interviews with company directors. In order to understand how the development and activities of Technium companies compared with those in the wider community, a second questionnaire was developed, and a survey conducted amongst a 'Comparison Group' of similar knowledge-based companies in the region. The following sections present the development, execution and findings of this study as follows:

- **7.1** Provides an overview of research and evaluation techniques used in this and the following Chapter
- **7.2** Describes some of the challenges in measurement of the Knowledge Economy
- **7.3** Describes major studies undertaken to assess the benefits of business incubators and Science Parks
- **7.4** Presents the development of the survey, including selection of the Comparison Group and design of the questionnaires
- **7.5** Defines the key questions being addressed by the survey
- **7.6** Presents the findings of the survey
- **7.7** Discusses the survey findings in light of the key questions described in 7.5
- **7.8** Provides discussion of the survey findings in the context of a Regional Innovation System

7.1 Practices – Quantitative and Qualitative Approaches

Much of the discussion in previous sections describing the Knowledge Economy relies on quantitative analysis of indicators. For example, Chapter 3 reported the correlation between academic attainment and regional wealth, and the relationship between innovation intensity and economic performance. These correlations emerge from a quantitative analysis of data.

However, the Knowledge Economy and businesses are complex and dynamic entities whose growth and performance is affected by a multitude of diverse factors such as management, market, investment, location etc, many of which are not quantifiable. It is often difficult to correlate improved (or worsened) performance to a particular variable or variables, especially across groups of companies that may operate in different markets, have dissimilar histories etc.

Furthermore the interrelation of issues makes it difficult to correlate individual factors. For example, does the improved performance of companies in region X relate to the support provided by programme A, B or C or what mixture thereof? For this reason, studies are typically conducted amongst large sample groups, identifying high-level issues.

Furthermore, causality or the directionality of linkages can also be difficult to ascertain. For example, does increased R&D make companies more competitive, or is increased R&D simply something exhibited by these companies that are more competitive. Although quantitative techniques exist to unravel this kind of simultaneity, data are rarely adequate to permit their use and therefore qualitative approaches are more appropriate.

The two forms of inquiry can be used together to lever their respective strengths and address their limitations. This may involve using different methods at different stages or throughout the study. Often a 'two-stage' approach is used in which qualitative inquiry determines the hypotheses that are to be tested quantitatively (Creswell 2002).

Section 7.1.6 discusses a number of studies where 'mixed-method' approaches have been adopted while section 7.4 and Chapter 8 describes how such an approach is applied in this survey and the work of the following Chapter.

In practice the boundaries between the two approaches can become blurred, such as where qualitative information is transformed into quantitative results. For example, companies may be asked whether they are satisfied with support available to them and they give a qualitative response – yes, no or some subjective assessment. This is then turned into quantitative scalar measure.

The problem remains though that however well indicators are crafted, or variables defined and measured, there will always exist limitations and it is important that these are identified and addressed.

7.1.1 Expert and Focus Groups

The interaction of individuals in a group can enhance output through stimulation of each other's ideas (Greenbaum 2000). Focus groups offer the opportunity for views to be tested and challenged in real-time (Marshall and Rossman 1999). The group develops its ideas by testing the hypotheses put forward by members where hypotheses and tests are derived from individual expertise and experience, thereby adding to the validity of any ultimate consensus (Forsyth 1990) However, a serious challenge in the use of focus groups can be dominant personalities that can affect the group dynamic and distort the input received (Fern 2001).

7.1.2 Delphi Groups

Pioneered by the RAND Corporation (Dalkey and Helmer 1963), the Delphi method was used in strategising a global nuclear war that fortunately never happened. Using groups of experts, the method uses (normally four) rounds of structured communication with individuals. The method typically involves providing structured questionnaires to experts by post, email or individual interview. Experts are selected and asked to provide anonymous input on particular issues. The collective observations of the experts together with information that they have requested is fed back to the group over several rounds. The technique has often been used in government planning exercises (Linstone and Turoff 1975). The theory of the method is that over these rounds (or iterations) the views of the group will converge to a consensus, informed by the views of other group members.

Strengths of the method include avoidance of group dynamic challenges such as overbearing personalities and views that can pose a challenge in focus groups, while anonymity allows experts express individual views. However, key challenges include developing the appropriate make-up of the expert group, ensuring accurate and unbiased review of results between rounds and formulation of the questionnaires (EU 2003b).

7.1.3 Questionnaires / Surveys

Surveys and questionnaires can be used to solicit both qualitative and quantitative responses from recipients and can be undertaken through a variety of media including mail, email, telephone and face to face. They can allow comparable information to be obtained from a sample in a structured manner. The length of the survey (both in terms of time to complete and length of a questionnaire) plays an important role in engaging the respondent. According to Brewerton and Millward (2001) surveys should not be too short (less than two pages) nor too long (taking more than 45 minutes to complete). Challenges facing questionnaires and surveys can include respondents giving answers they believe to be desired and lack of care in their completion, e.g. respondents simply ticking 'yes', 'satisfied' or selecting the middle option for all questions. Carefully structuring surveys to avoid long runs of similar questions and combining questionnaires with interviews can help address this challenge (Brewerton and Millward 2001). To allow respondents to provide a full spectrum of possible answers, an approach such as the 'Likert scale' can be used, where levels of agreement can be requested in relation to neutrally posed statements.

7.1.4 Individual Interviews

Information can also be obtained through interviews. This can avoid challenges of dominant personalities in groups and working with individuals has been shown to improve productivity, particularly in brainstorming activities (Williams and Karau 1991). Working with people individually also allows the more in-depth discussion of issues and increases willingness to share information (Greenbaum 2000). It is, of course, more time consuming.

This method lacks the group dynamic and relies on the ability of the interviewer and the interviewee being articulate and perceptive (Creswell 1994, Greenbaum 2000). Another challenge is maximising the validity of responses from individuals (Brewerton and Millward 2001, Greenbaum 2000). However feeding results into a process where it is reviewed by peers, such as in a focus group or Delphi group approach, can address this (Brewerton and Millward 2001).

7.1.5 Recording and Analysis

The accurate and effective recording and interpretation of information is critical to all methods of inquiry, especially those that rely on information capture by an interviewer or facilitator. In order to ensure reliability of information capture and that facilitation does not create bias at group sessions, great care must be taken (Creswell 1994). Issues to consider include using facilitators in pairs, and where relevant, gender balanced (Greenbaum 2000).

7.1.6 Practices – Mixed Method Approaches

While quantitative and qualitative approaches are often considered separately there is considerable cross-over between the two. For example, responses to qualitative surveys are often reported quantitatively when grouped together – "*8 out of 10 cats prefer…*" is one example. However, a more relevant one is perhaps that cited in the EU guidance on evaluation (EU 2003b), which describes aggregating results to qualitative surveys to provide findings such as "*50% of those interviewed said they had benefited from the programme*".

Mixed method approaches have been used in many studies, including ones that, *prima facie,* appear to be purely qualitative. The DTI study of clusters in the UK (DTI 2001) analyses Standard Industry Classification (SIC) codes for businesses within regions to establish levels of employment within industries in order to identify clusters. It builds much of the understanding from qualitative information gathered through interviews, particularly with regard to 'institutional thickness' (i.e. the absolute number of relevant local organisations and the density of their networks) – which is fundamental to cluster theory.

The approach of developing a high-level picture from quantitative data, followed by subsequent qualitative research is seen in the work of North et al. (2001) investigating public sector support for SMEs in the London Lee Valley region. They correlated the findings of telephone and face-to-face interviews with the experiences of 100 businesses in the region. A high-level example of an approach of using a mixture of questionnaires and is provided by the European Commission's study of clusters (EU 2003). This was adopted partly because the understanding of the concept and data collection methods of member states varied widely and data were often incomparable.

Closer to home, applications of mixed approaches include the 'Cyfenter' research programme identifying challenges faced by minority groups in entrepreneurship (Akhtar and Rolfe 2002) and the development of a regional Knowledge Economy Strategy for Swansea Bay – Waterfront and Western Valleys (Davies et al. 2007). The regional Knowledge Economy strategy development used a mixture of techniques to;

- identify regional challenges to the development of a regional Knowledge Economy
- develop recommendations from integration input from an Expert Group and desk research
- produce an integrated strategy and action plan endorsed by the region as a whole

Elements of this work feature in the work of this study and are described in further detail in the relevant sections.

7.2 Measurement of the Knowledge Economy and its Challenges

Earlier chapters have described the Knowledge Economy, knowledge-based businesses and business incubation/development and introduced and used a variety of measures and indicators. This section discusses some of the challenges and limitations of these indicators and where/how care must be taken in their use.

7.2.1 Inherent Challenges – Statistics and Intangibles

"*Statistics: The only science that enables different experts using the same figures to draw different conclusions*"

Evan Esar, American Humorist 1899-1995

Economics has primarily focused upon the production function of the factors labour, capital, materials and energy, where the increase in supply and productivity of each of these lead to economic growth (Samuelson 1999). Knowledge and technology were traditionally seen as external influences that affected the function, either by increasing productivity of factors or producing new products or processes (OECD 1996).

It is difficult to measure and understand the development of the Knowledge Economy (described in chapter 3) for it is based on activities that are intangible and immaterial (Leadbeater 1999). Immaterial products exist such as information, judgement, entertainment and advice, which are often unique and incomparable (in regard to what each is and its value to both its producer and the recipient). Intangible assets such as intellectual property, know-how and brands pose a similar challenge to measurement.

The OECD describes four principal reasons why knowledge cannot be used in the same manner as the above traditional indicators;

- *The absence of stable formulae to translate inputs into knowledge creation into knowledge outputs*
- *Inputs are difficult to map as comparable accounts do not exist as for traditional indicators*
- *Knowledge lacks a systematic price system that would serve as a basis for aggregating pieces of knowledge, each of which is unique*
- *New knowledge creation is not necessarily a net addition to the stock of knowledge and obsolescence of units is not documented*

(OECD 1996)

Analysis of the knowledge-based economy has primarily focused on those inputs (such as R&D expenditure, households with broadband) and outputs (such as patents, new products, degrees awarded) for which data are gathered by and comparable between nations (OECD 1997).
In fact the internationally tracked indicators for the knowledge economy are rather limited and include (OECD 1996);

- *expenditure on research and development (R&D)*
- *employment of engineers and technical personnel*
- *patents*
- *international balances of payments for technology*

However, analysis at the regional and sub-regional level is even more challenging due to the lesser availability of data (Gripiaios et al. 1997, Boddy 2005).

7.2.2 The Problem with Indicators

The following sections look at aspects of the knowledge economy and discuss some of the challenges in their measurement and the use of indicators.

Traditional economic indicators such as R&D expenditure and personnel involved in R&D are regarded as rather limited in their ability to assist in tracking the development of the knowledge economy and inform policy development (OECD 1996, Boddy 2005, WAG 2004), particularly with regard to innovation (DTI 2003).

Further complicating the situation is the fact that what may seem to be relevant and straightforward indicators have sometimes shown little, no or even negative correlation with the overall development of the knowledge economy. This is observed by Quah (1999) describing the work of Robert Solow who identified '*productivity paradoxes*', where despite increasing investment in computers and a rise in the number of engineers and scientists, economic growth in the United States slowed down during the latter half of the 20th Century. This is shown in Fig. 7.1 below, from Quah (1999).

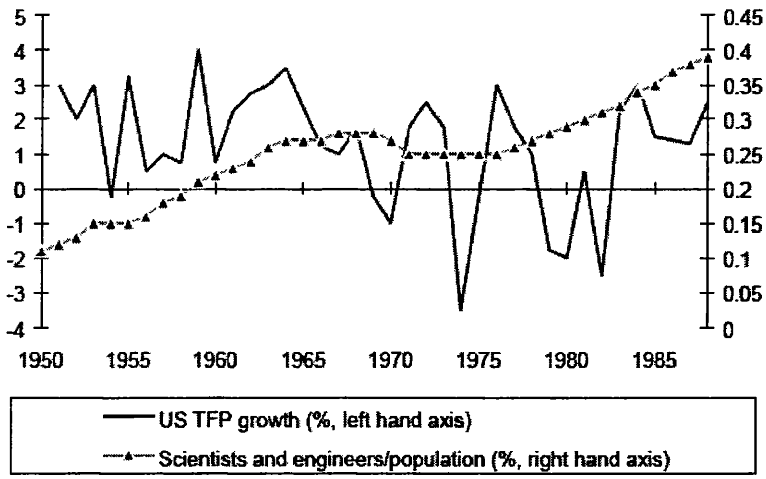

Fig.7.1 US Total Factor Productivity (TFP) Growth and % of scientists and engineers in the population, cited from Quah (1999)

Quah's (1999) solution to this paradox is to change the relevant indicator to be the '*outputs*' of these scientists and engineers rather than their number. Scientific and engineering endeavours create technologies that can often result in intermediate products such as patents or other publications that can be quantified, prior to becoming a new product or service. Ultimately it will be through the final products that the contribution to the economy will be captured.

7.2.3 Human Capital

Human capital aspects of the Knowledge Economy are studied using a variety of measures such as level of educational attainment achieved by portions of the population, migration of knowledge workers, % of workers involved in knowledge activities etc. These can be translated into a range of quantifiable indicators (Leadbeater 1999) including;

- Number of graduates
- Expenditure on Training and Development
- Employee turnover
- Skills diversity
- Ethnic diversity

Linking these indicators to the value of a company is difficult, though as described in Chapter 3, there is a clear correlation between higher level skills and improved company performance. One approach to this is described by Leadbeater (1999) following the work of Rosett (2001) who examined the 'value' of an (albeit non-knowledge economy) company's human capital. He treated human capital as an intangible asset and examining the value of employment contracts, demonstrated that this encompassed value greater than all tangible assets by a ratio of 1.5. As contracts in knowledge-based firms will generally be negotiated in line with the skills and expertise of the worker this provides a financial 'proxy' for measuring human capital.

Tacit knowledge poses a problem as it is unique to each individual, though more highly qualified workers are regarded as being more likely to have acquired further knowledge beyond that of their formal education (Boddy 2005).

Rocha (2004) also highlights the difficulty in measuring 'quality' of jobs due to the large number of variables, including wage level, job satisfaction, morale, hours worked, pension provision, security of employment, child care, health benefits etc.

7.2.4 Innovation

Measuring innovation is difficult in that it relies on many factors beyond the creation of new knowledge. As described in chapter 3, it needs to be considered in a much broader sense and it is for this reason that 'outputs', such as patents and new products or services introduced are often used as proxies. This is in addition to inputs such as academic publications, R&D expenditure, employees involved in R&D etc.

Care needs to be taken in not mistaking 'intermediate' products such as patents for the result of innovation. As defined by the DTI (2003), innovation is the *successful* exploitation of new ideas, which implies that the product or service must have found its way into the market. This is captured by Leadbeater (2003) in his description of commercialising intellectual property, whereby;

"*Intangible assets gain their value when they are deployed in competition to serve customers*"

Underlining this challenge of intangibles, and the point that the Knowledge Economy and innovation are not the reserve of Science, Engineering and Technology, are the cases of Mi and similar companies. While 'Big Mac' sauce may be a technological marvel of the 20th Century, the products and services of McDonalds are in general not particularly technologically advanced. However, its intangible assets account for 77% of the company's market value (Leadbeater 1999, Hoovers 2007). This is a result of innovation in development of a brand, business process and skills base within the company.

In order to consider intangible assets, novel approaches to accounting have been developed that capture more than traditional company financial information. Examples include (Leadbeater 1999);

- **The European Foundation for Quality Management (EFQM) Model** – This model captures a range of non-financial measures including resources, business processes and results, leadership and customer satisfaction.
- **The Balanced Scorecard** – Developed in 1992 by two American academics the Scorecard captures measurements of innovation and renewal, such as percentage of revenues from new products, R&D success rate etc.

One aspect of innovation where measurement is particularly difficult is in evaluating the impact of publicly funded research (OECD 1996). Only where formal linkages and clear evidence exists, such as spin-out companies and collaborative research projects, is the relationship relatively clear.

R&D

While expenditure on R&D is often used as a measure, of the value of investment is not necessarily indicative of the value of the result as such endeavours are not always successful. The results can vary from being worthless to of massive value. The concept of potential 'worthlessness' may seem harsh, however studies of R&D in the EU prior to 1995 have shown that 30% of activity duplicates work already done elsewhere (Trotter 1995). While additional knowledge may have been developed and existing knowledge better understood thanks to such activity, use of the knowledge may be precluded if the IP has already been protected, such as by competitor patenting. In fact if such R&D were followed through to the marketplace it could result in a negative return due to subsequent litigation.

R&D expenditure is also limited as it refers to all manner of activity (including both research and development) and therefore to activities at different points in their evolution (Leadbeater 1999). While some studies break down expenditure separately into 'R' and 'D' and sometimes further to 'basic research' this still leaves a challenge within each type.

Patents

As described above, patents are often used as a 'proxy' measure of innovation. This applies to international, national and regional contexts. They are regarded as a more insightful indicator alongside R&D expenditure for they represent a further investment, an appraisal of the invention in terms of novelty, and presumably within the company for value.

Many studies of both national and individual firm innovation performance have focused on counting patents granted, known as Simple Patent Counts (SPC). These data are readily available from national patent offices making these easy to collate. However, not all patents are equal in value. An internal study amongst the 29,000 patents held by Dow Chemicals found that 200 were key to the company, while others were used but not important and others were not used at all (Leadbeater 1999). This is not to say that it is simple to classify unused or the 'less-important' patents and then save money on renewal fees. Companies often hold 'portfolios' of patents where the whole is worth more than the sum of the parts, and also use 'pickets' of patents to surround and protect critically important patents. Some studies have even shown that many inventions, in particular university technologies, are so far from market that they can be considered at point of licence as being of limited initial value (Jensen and Thursby, 2001, Thursby et al. 2001).

A patent will however provide a measure of protection for the licensee with regard to the potential market and when developed may be of significant value, i.e. helping to clarify freedom to operate and monopoly over the technology. It is at the outset of taking an invention to market that raising finance can be most challenging, particularly for radical ventures such as those arising from university research (Auerswald and Branscomb, 2003). Raising finance in this period of technology development is a critical challenge for firms who need to develop sufficient assets and markets before competitors work around their IP (Audretsch and Mahmood, 1991).

Analysis of patent bibliometrics based upon the citations included in patents can provide a window on the technology, its inventor and the invention value. This mirrors the technique used by academics to appraise academic publication productivity (Narin, 1994). One study examining US patents granted to German companies quantified the average value of a single US citation as adding $1m of value to the invention (Harhoff et al. 1997). Citation analysis has been used to investigate various phenomena and studies have focused on issues such as knowledge spillovers (Jaffe et al. 2000, Maurseth and Verspagen, 2002), international knowledge flows, the value of inventions (Harhoff et al. 1999, Jaffe et al. 2000), the impact of publicly-funded research (Jaffe and Trajtneberg, 1998, Davies et al. 2007) and competitive strategy (Watts et al. 1999 and Jaffe et al. 1990).

The work of IP Wales has provided an insight to the innovative activities of Welsh production firms compared to neighbouring regions (Moore and Mainwaring 2004). 2049 Welsh production firms were examined together with 700 of their peers from each of the other regions: Republic of Ireland, Scotland and South West England. The study found that remarkably few companies were engaged in patent activity and Welsh companies were the most active. However, Moore and Mainwaring note that much of the Welsh activity relates to many companies with single patent holdings, suggesting a rather non-strategic approach to intellectual property management amongst Welsh firms.

7.2.5 Infrastructure and Enterprise

Described in the previous section were limitations of economic indicators in studying innovation activity; however this extends to their use in understanding and evaluating infrastructure and enterprise within the knowledge economy. This challenge is noted by the European Commission in regard to the advantages of clusters (EU 2003) as;

"*It is worth noting that the reality of the advantages* (of clusters)*...has seldom been checked on the basis of scientific performance indicators...the majority of studies...giving qualitative explanations on the performance of clusters...*"

Entrepreneurship

Entrepreneurship is typically simply measured by number of business formations. However, more complex methods such as the 'TEA' measure (mentioned earlier in chapter 4) used in the Global Entrepreneurship Monitor (GEM) survey have been developed (GEM 2004). This measure was developed to address a lack of internationally comparable data and provide a more in-depth understanding of entrepreneurship (Wong et al. 2005). However, as Rocha (2005) notes, there is a lag between an increase in levels of entrepreneurship and variation in economic growth. This occurs as it takes time for businesses to become established, grow and feed benefits into the economy as a whole.

Businesses and Functions

Counting business 'stocks' also presents similar challenges. Success of a technology based start-up can make the firm, and/or its IP, a target for acquisition by larger companies, including from overseas. This can effectively cause the rapidly growing technology SME to 'disappear' (Almeida and Kogut 1997). This means that care must be taken in understanding what can and does happen to each individual company.

Growth of businesses is typically measured by determining changes in turnover, employment and profitability (Robson and Bennett 2000), with employment being of particular importance to governments and the economic development agenda.

7.3 Study and Evaluation of Incubators and Science Parks

7.3.1 Overview of Research

The study of business incubation and incubators has developed over the years alongside the concept of business incubation itself. Hackett and Dilts (2004), in an overview of this evolution, suggest distinct phases of research since the concept started receiving significant interest around 1984, namely;

- ***1984-1987 - Incubator Development Studies*** *- defining what incubation is, defining lifecycle models of incubators etc.*
- ***1987-1988 - Incubator Configuration Studies*** *- identifying critical success factors for incubation, incubate selection strategies etc.*
- ***1990 - 1999 - Incubator - incubation impact studies*** *- investigating whether incubators have achieved their strategic goals and quantifying economic impacts etc.*
- ***1996 - 2000 - Theorisation about incubators/incubation*** *- studying critical networks, founder characteristics, virtual incubators etc.*

Source: Adapted from Hackett and Dilts (2004)

Research has ranged in scale from examining the internal workings of individual incubators and sometimes a handful of companies therein (Scherer and McDonald 1988) to large scale studies encompassing incubator and science park activity across the entire United States. One of the key challenges in evaluating the effectiveness of incubators/science parks is identifying and investigating suitable 'control' groups with which to compare and contrast (Luger and Goldstein 1991). It is for this reason that much of the research conducted to date has been more descriptive than analytical in nature (Hannon 2005).

Central to the role of the incubator is to support growth and improve survivability of its firms (Hackett and Dilts 2004). For this reason the survival rate and growth of firms are key indicators of performance, where growth can be in terms of employment, turnover, profitability or a combination thereof. Measurement is often taken at the graduation of the firms into the wider community as part of an 'exit rate' metric (NCEA 2004). It should be noted that companies can 'exit' an incubator for a number of reasons relating to the failure or success of the business and therefore the nature of each departure requires consideration.

Evaluating in Context

As described in Chapter 4 business incubators are often used as economic development tools. However, they, along with their tenant companies, often face challenges themselves in their development. For example, an incubator established in an area that has high levels of entrepreneurship, is located near centres of knowledge generation and enjoys a high availability of seed funding would be well paced to become populated with growing businesses. However, these are not always the prevailing conditions where economic development intervention is required. Furthermore, the manner in which the incubator links to the wider community and economic infrastructure are key to its success (NCEA 2004, Lewis 2004).

For these reasons, the challenges faced by the incubator need to be considered in its evaluation. The UK Science Park Association lists four key factors (UKSPA 2003);

- The age of the Science Park
- Its physical location (such as on a university campus)
- The stage of development of the Science Park - Start, Growth, Maturity or Diversification
- The maturity of the Knowledge Economy in the region

For Technium the first three factors are relatively straightforward;

- Age – Technium as a whole remains a relatively young initiative. The first Centres have been open for some time and are starting to see their first graduates. However, the network as a whole is still young, highlighted by the fact that not all Centres are yet open
- The Technium network boasts Centres in a range of locations across the region. Some are based close (or even on) a University campus, while others are relatively remote, and some are based in particularly challenged areas
- None of the Centres, with the exception perhaps of Technium Swansea, has yet reached the 'Growth' phase

The 'maturity' of the Knowledge Economy is of particular interest in the case of Technium. It is also, UKSPA state, the most critical factor in the success of a science park. UKSPA provides three possible levels of maturity (UKSPA 2003);

- ***Knowledge Heartland Economy*** *where all elements of the sub regional knowledge economy are fully established and pathways working well*
- ***Developing Knowledge Economy*** *where most elements of the sub regional knowledge economy are established with some pathway or capacity restrictions*
- ***Economic Development Priority Area*** *where major elements of the sub regional knowledge economy and/or pathways are either missing or constrained*

The mission of Technium is itself to '*embed the Knowledge Economy within the region*' (WAG 2004c), which implies some limitation to its development; though at the same time suggests there is something to embed. Therefore it could be argued that Technium exists in a region that falls somewhere in the second or third of these levels. However, it should be remembered that the Technium network is spread across quite diverse regions, where the strength of the foundation of the Knowledge Economy may be patchy. This would reflect the observations on the regional Knowledge Economy in Chapter 3.

7.3.2 Major Studies of Incubation and Science Parks

Numerous studies have been undertaken to examine science parks and incubators with a variety of primary goals including understanding their impact upon regional economies (Luger and Goldstein 1991, UKSPA 2003, NAEC 2004) and identifying best practice (CSES 2002, NBIA 2003). Described below are three studies that cover each of these;

Luger and Goldstein – US Science Park Research

As described earlier, impact studies of incubators and science parks took off at the beginning of the 1990s. One particularly extensive study was that undertaken at the beginning of the decade by Luger and Goldstein (1991). This research involved surveying all 116 research parks in existence at that time, with in-depth case studies of three of the most successful, namely Research Triangle Park in North Carolina, Stanford Research Park in California and University of Utah Research Park.

The study develops an understanding of the economic impact of research parks, not only in terms of enterprise and employment, but also in developing a region's innovative capacity. A quasi-experimental approach was applied to compare regions that had science parks with those that did not. Comparable municipalities were identified within the same region and data were collected using surveys amongst park managers and businesses within and outside of the parks. These surveys captured information on employment, personal income and expenditure, allowing the economic impacts of the parks to be evaluated.

The study concludes that science parks/incubators are most likely to be successful and have a meaningful impact where there already exists a mass of knowledge-based activity including academic centres. It also observes that some of the most important impacts are those which are indirect. These include not only effects such as indirect and induced employment but the reputational benefits that can be enjoyed by associated universities etc.

NBIA Study

The National Business Incubation Association has carried out numerous studies of business incubation in the United States. One of the most recent studies focuses on the understanding of technology incubators, their performances and practices (NBIA 2003). Undertaken by leading expert in technology transfer, Louis Tornatzky, the study examined 79 incubators across the US, representing around 24 percent of US technology incubators. Each of the Centres was surveyed using a questionnaire with further in-depth interviews conducted in 15 of them. All information was collected from incubation managers as the authors acknowledge the difficulties of gathering information at the individual firm level. The study was designed to test the strength of linkages between assistance and company performance (in terms of employment and sales growth). While there existed little correlation between business support and employment or sales growth, a relationship was found between support and 'secondary' business outcomes including equity investment, patents and licensing of intellectual property.

UKSPA Evaluation of the UK Science Park Movement

The United Kingdom Science Park Association (of which Technium is a member) has undertaken reviews of incubation in the UK, which have led to the development of a number of good practice guides for business incubation, health and safety, landlord and tenant matters etc. More recently the Association, in partnership with the DTI Small Business Service, has undertaken a review of the impact of the Science Park movement upon the UK economy (UKSPA 2003).

The review found that the 'science park movement' was home to some 1,700 clients employing over 41,000 people. Interviews were held with science park managers and companies both within and outside incubators/science parks. The survey included 617 businesses located within incubators/science parks and 259 outside, from throughout the UK.

These interviews led to a number of observations of that support the message of the positive impact of incubation on and science parks. Tenant companies, compared to those in the wider community exhibited;

- Higher growth rates, both in employment and turnover
- More successful access to venture capital, public sector and angel investor finance
- The launch of more new products and services
- Employment of a higher proportion of scientists and engineers

UKSPA has also studied Technium as part of a review of business incubation in Wales for the former WDA. This is described in Chapter 5, along with other reviews of Technium.

7.4 Measuring Knowledge Enterprise and Innovation

7.4.1. Overview

The relatively small number of businesses within the Technium centres makes it easy to define the population to be examined, though presents a small sample from which to determine trends. There is also a considerable diversity of occupants:

- **Business type** – including academic spin-outs, inward investors and other start-ups
- **Age of business** – some companies are recently formed while others are well-established with global customer bases (problems of definition are exemplified by one company describing itself as a "*17 year old start-up*")
- **Technology/Market involved** – companies are involved in sectors as diverse as ICT services to oil and gas exploration

Technium thus presents the opportunity to investigate how such a mixture of businesses interacts (or not), along with the effect this may have on innovation and business development.

The approach combines questionnaires and semi-structured face-to-face interviews as seen in studies such as those undertaken by North et al. (2001) and Lewis (2001). The questionnaire was developed by the author incorporating feedback from the Technium managers who had kindly agreed access to their tenants. The issues investigated were:

- **Enterprise and Employment** – investigating aspects such as business start-up and development, and skills within the businesses
- **Innovation** – examining the innovation activity and its intensity within companies. The generation and protection of IP was investigated along with collaborative innovation activity.
- **Networking** – exploring the nature and intensity of networking activity by companies. This encompassed public and private networks and geographical spread
- **Technium Support** – understanding the role of Technium and the support it provides to companies
- **Additional Questions** – further questions were included to appraise companies' usage and perceptions of Technium facilities

These foci are in keeping with the frameworks used in other studies such as those undertaken by the Danish Government's Agency for Enterprise and Construction (NAEC 2004) and undertaken by the Centre for Strategy and Evaluation Services for the European Commission (CSES 2002). Each of these is described in more detail in the following sections;

Interviews were conducted by the author together with the Centre manager or other Centre representative. Reassurance was given to all companies that responses would only be used in an anonymous aggregated manner and no company specific information would be provided to any third-party.

7.4.2 The Control/Comparison Group

As described earlier in Chapters 2, 3 and 5 a critical difficulty in determining the effects of business development support interventions is in establishing a benchmark against which to make comparison. Rather than simply compare activities and performance to broad economic trends and indicators, the evaluation used a quasi-experimental approach where Technium companies are assessed alongside a comparable group outside of Technium.

Technium is a public support initiative and it would have been neither desirable nor possible to exclude businesses at the outset from seeking and obtaining its support in order to establish 'treatment' and 'control' groups. As the treatment group is effectively defined as those companies within Technium it remains to identify a comparison group that comes from a similar 'population'. The population from which Technium companies are drawn includes both indigenous and inward investing enterprise though can be broadly defined by;

- **Geography** – The population of the Technium, and therefore control, group operate within the Objective One regions of Wales. This therefore defines the population spatially.
- **Business Type** – Technium companies come from a population of knowledge-based businesses that express desire to grow. This knowledge creation/exploitation is therefore required in the control group.
- **Business Age/Origin** – The Technium group of companies within do not all fall within any particular description of age or nature such as start-ups, inward investors etc. As many other initiatives focus on strictly defined groups of businesses this poses a distinct challenge in identifying a control group from the same population.
- **Timescale** – The period of operation and development under investigation is the start of the Objective One (and Technium) period from 2000 to present. This defines the population temporally.

Fortuitously, another initiative operating within the region, Intellectual Property (IP) Wales, offered a grouping of companies drawn from a similar population as Technium. The IP Wales initiative, described earlier in Chapter 2, provided assistance to companies in the identification, protection and exploitation of their intellectual assets. With regard to each of the aspects of the population the considerations were as follows;

- **Geography** – IP Wales operates within the same territory as Technium providing assistance to Welsh companies, primarily within the Objective One areas. This consideration was made as Objective One status implies companies in such regions may face certain disadvantages that would affect their performance and activities. Furthermore, numerous support initiatives have only been available in Objective One areas, and those initiatives which are pan-Wales may have offered a different level of support to companies located in Objective One regions. Therefore this complication is avoided by only including in the comparison group the companies within such regions.
- **Business Type** – The support provided by IP Wales was aimed at businesses creating and exploiting knowledge.
- **Business Age/Origin** – IP Wales support, such as free advice on IP, is available to businesses of all ages and origins within the spatial area described above. Its primary focus is on SMEs and the size distribution of its supported companies is similar to that of Technium.
- **Timescale** – IP Wales was developed at the same time as Technium and supported companies during the same period

With the assistance of the Director of IP Wales, assisted companies were contacted in accordance with the data protection policy of only allowing contact details to be provided to parties approved by IP Wales. The contact details of the companies were provided for the survey with details of location and broken down by type of assistance received namely;

- **Free IP Guide** – Companies that had signed up for free information guides about IP issues
- **IP Audit** – Businesses that had received 'audits' of their IP including its identification and suggestions for its protection and exploitation
- **Financial Assistance** – Companies that have received grants to assist with costs of acquiring IP protection, such as in making patent applications

As the first and to a lesser extent the second groups of companies assisted could have been of a knowledge-based nature to only a limited extent, it was decided that the control group would be selected from those companies that had received financial assistance. This would give confidence in matching IP Wales companies with the added benefit that companies which had received support would be more likely to participate in the survey. As none of the questions relates to the impact (actual or perceived) of the IP Wales assistance there should be minimal risk of a biased response. It was from this 3rd set that the control group was drawn. Technium companies which also appeared in this grouping (of which there were three) were removed as they would be subject to the Technium questionnaire and interview.

7.4.3 The Survey

The questionnaires and interviews are described in general terms below, with details left to subsequent sections.

Questionnaires

Two questionnaires were developed for the survey; one for Technium companies and the other for the IP Wales control group, both of which are included as appendices 9 and 10. The Technium companies' questionnaire was the more detailed of the two as it was felt that there would be more opportunity to interact with them and gather information, and it was with this group that there was the greatest range of issues to explore. It was made explicit to Technium companies that their responses would be treated confidentially and would in no way affect the support available to them or their tenancies within the Centres.

Questions were posed in a neutral manner and allowed for a full spectrum of responses so as to not introduce any bias. An example is shown below, in a question investigating anticipated future benefits of Technium.

How do you believe Technium will affect the development of your business in the future? (please tick)

Very positively Positively No differently Negatively Very Negatively

Fig. 7.2 Example question from the Technium company questionnaire

With regard to questions concerning frequency of use or qualitative perceptions, a standardised scale was adopted in both questionnaires, as follows;

Satisfaction:

Complete satisfaction, mostly satisfied, indifferent, mostly dissatisfied, completely dissatisfied

Frequency:

Everyday, twice a week plus, weekly, infrequently/monthly, never

Care was taken to avoid pitfalls highlighted in guidance on survey development, (Brewerton and Millward 2001) namely;

- Unfamiliar words or jargon
- Ambiguous or imprecise words or questions
- Complicated wording
- Double-barrelled questions
- Leading questions

The questionnaire was piloted with companies who were particularly accessible to the author to determine time requirements and identify any issues. The first version of the questionnaire contained some duplication and ambiguity in certain questions, such as whether percentages or absolute values were requested. Appropriate amendments were made to address this.

The Technium company questionnaire and survey took approximately 30-40 minutes to complete and comprised eight pages, while the control group questionnaire was three pages in length and took around 10 minutes to complete. These lengths of questionnaire are in keeping with practices advised to engage the recipients (Brewerton and Millward 2001).

The questionnaire used with the comparison group was designed to be as concise as possible while gathering the maximum information possible, and is a complete sub-set of the Technium companies' questionnaire. The questionnaire was circulated to the comparison group as an 'e-form' to make it as simple as possible for companies to complete and return it. This meant that no print-outs, envelopes or stamps were required. However, an alternative postal address for responses was also provided.

An incentive (of being entered into a draw for a bottle of Penderyn Whisky) was also offered to encourage return of completed questionnaires. It was of course made clear that chances in the draw were in no way related to the nature of responses provided in the survey.

The content of both the questionnaires and interviews are described in the following sections, with the relevant parts of each questionnaire referenced below the section headings.

Semi-structured Interviews

The distribution of the Technium questionnaires was followed by semi-structured interviews with the company principals. This was done to assist in achieving a high response rate and to pursue issues raised by the companies, particularly in regard to their experiences of Technium.

The choice of interviewer for each company depended upon with whom the company in question would feel most comfortable to divulge and discuss potentially sensitive information and to whom they would be least likely to provide answers of any bias. In the case of Technium Digital the interviewer was the author, who has worked alongside the companies in his role as Project Manager in Swansea University's Department of Research and Innovation. The independent role of the interviewer assisted in soliciting unbiased responses, while also putting companies at ease in discussing their confidential information.

For companies at Technium Swansea for it was felt that the companies would be most at ease of the survey also involved the Centre Manager, Mr. Richard Harris. Mr Harris has a close working relationship with the companies, making him well-placed to conduct the interviews. Therefore Mr Harris was also involved in conducting these interviews. During these interviews it was made clear to the companies that criticism they may perceive as either positive or negative was equally required, and would not be interpreted as targeted at any individuals. This was done to solicit the most full, frank and honest answers and opinions possible.

7.4.4 Enterprise and Employment

(Technium Companies Questionnaire Sections: 1, 3, 6 and 8)
(Comparison Group Questionnaire Sections: 1 and 2)

Since the establishment of first Centre, subsequent development of the initiative has targeted addressing the European Lisbon agenda of 'Growth and Jobs'. Therefore, it is important to measure the key indicators of growth in employment and turnover, as done in most studies of this nature (North et al. 2001). The earlier part of the study described in Chapter 6 was designed to capture the employment impact of Technium. However, to understand the impact of Technium, the questionnaire and interview process was used to investigate the nature and 'quality' of jobs created within the companies.

Business Development – Entrepreneurship

While the establishment of a company is itself an indication of entrepreneurship, the research aims for a deeper understanding of the entrepreneurs themselves and the role Technium plays in supporting the entrepreneurship process. The questionnaires and interviews addressed these issues by examining the following;

- **Entrepreneurs** – Founders were asked how many company formations they had been involved with during the previous 5 and 10 years. This was to establish both the experience and entrepreneurial spirit of those involved with Technium companies.

  The background of company founders was investigated to see whether they came from academia, industry or elsewhere. As the Centres are interlinked with Swansea University and other academic institutions the author wanted to test whether there existed a strong showing of 'academics' in Technium companies. The questioning allowed respondents to specify a multiplicity of backgrounds of founders.

  The age of the founders was also investigated. Wales performs strongly with regard to graduate start-ups (WAG 2004) and the survey aimed to establish what (if any) role Technium had in supporting this phenomenon.

- **Entrepreneurship** – Along with investigating the sector within which a company operated, the phase of its lifecycle upon entry to Technium was elicited, together with whether the company started with an 'idea', 'prototype' or 'product'. This was done to assess the maturity of the business upon entry.

- **Support** – While Technium aims to provide an environment to support the growth of businesses, the survey aimed to establish the role that the availability (or at least the perception at the outset of availability) of this support played in assisting the entrepreneur to establish their firm, and particularly within the region. This applied to start-ups, local SMEs and inward investors which may be part of a larger firm.

With the exception of issues relating to choices and perceptions about Technium, all of the above also applied to the Comparison Group. This allowed comparison of Technium entrepreneurs with those in the wider community.

The survey work was supplemented by research examining survival of firms. As business incubation is intended to improve the survival rate of young enterprises this is an important indicator in assessing effectiveness (Hackett and Dilts 2004). The Companies House database, together with evidence from Technium managers, was used to estimate failure rates.

Business Development – Turnover Growth and Operations
The turnover of companies was surveyed to track growth of companies, alongside other indicators including employment. As many of the companies are in particularly early phases of their development, and inward investors are parts of much larger, often multinational, corporations, this made 'profitability' a difficult and potentially inappropriate measure. However, this may become relevant to future research tracking the prospects of Technium companies, especially beyond graduation.

A breakdown of turnover by territory (Wales, UK, Global) was investigated to establish whether Technium companies are competing on a 'global' stage. Other indices included;

- **Business Plan objectives achieved** – Each company entering Technium has its business plan evaluated and approved. The survey asked companies whether they are performing in line with these projections.
- **New projects** – New projects started by the company could relate to in-house developments, collaborations with other companies or other projects.
- **New business started** – Though not tracking volume or value of sales this indicator was included to identify when trading commences / grows for a company.
- **Innovation** – Standard metrics relating to introduction of new products/services were also included (these are fully described later in this section).

Companies were asked what proportion(s) of their customers are end-users (either direct or via distributors) or other companies who add further value. This provided a picture of where in the value chain Technium companies operate and whether they have direct interaction with end-users.

Business Development – Employment Growth and Graduate Skills

The employment in companies was investigated, together with how it had developed over time. This was done to compare the both the size and growth rates of Technium Companies with those of the Comparison Group cohort.

The 'Brain Drain' discussed in Chapter 3 is linked to the lack of graduate opportunities in the region and the survey asked companies: whether they employed graduates; whether graduates employed had graduated in Wales; and whether they had been recruited since the company moved into Technium. Companies were asked whether they perceived such skills to be beneficial. This was done to reflect and contrast recent views which highlight both the importance, and disappointment sometimes found, of graduate skills (CBI 2004, HEFCW 2006a, Leitch 2006).

The type of graduate skills possessed by companies was investigated to ascertain the proportions of science, engineering, business and other skills. It was asked what proportion of employees held a post-graduate qualification. This was because an ever-increasing proportion of the population possesses a degree and the survey intended to test not only whether this group is well represented amongst Technium employees, but whether it includes the highest achievers and skills levels.

As described in Chapters 3 and 4, wage levels provide an important indicator of a project's contribution to regional income and 'quality' of jobs. The survey captured wage information, along with a breakdown of wages by job type to identify whether the employment was of the higher level envisaged. For the later interviews with companies in Technium Swansea this information was recorded in the format required for monitoring of EU funded projects.

7.4.5 Innovation

(Technium Companies Questionnaire Section: 2)
(Comparison Group Questionnaire Section: 1)

Innovation Activity and Intensity

The survey did not focus solely on quantifying intermediate products of innovation such as patents but encompassed other indicators of innovative activity, asking the percentage of employees involved in innovation and the number of products/processes have been introduced (i.e. final products of innovation).

The questionnaires asked whether they generate and protect IP. While it was presumed (due to the nature of the companies) that most respondents would make this claim, this question is intended to verify the 'knowledge-based' credentials of the businesses. The type of IP involved in the company was also examined namely; patents, copyright, trademarks, trade secrets and know-how. Also examined was the proportion of employees involved in creating IP/R&D. This was to investigate the intensity of innovation activity with the companies.

These questions were accompanied by a search of patent and trademark databases to establish what, if any, registrations were held by the companies. It is acknowledged of course that some may not have been published or granted at the time of these searches. These searches examined forward and backward citations to investigate potential indicators of collaboration, value and firm strategy (as described in Chapter 3).

Collaboration in innovation was also investigated by the survey. Companies were asked whether they innovated in partnership with other companies, either within or outside Technium, by both geography and size. This was to understand the scope of collaborations and where in the value chain of innovation the companies operated. The nature of collaborations between Technium companies was investigated further, with the interviews used to obtain details.

With the exception of questions relating to collaboration amongst Technium companies all questions were included in both the Technium and comparison group questionnaires.

Sources of Innovation

As described in Chapter 3, innovation can be driven from a variety of sources and the diversity of this drive is at the heart of Open Innovation. To investigate this, companies were asked as part of the questionnaire and interviews, which of the following drive(s) their innovative activity;

- **In-house development** – following the traditional 'research lab' model of internal innovation, developing in line with existing company knowledge and capabilities
- **Response to specific customer needs** – to identify interaction with customers to innovate, along the lines of 'lead user' approaches
- **Ad-hoc improvements allowed by technology** – whereby innovation fed through the supply chain is integrated into products
- **Maintaining/gaining competitive advantage** – to identify whether innovation is 'market-led' and if it is a strategic activity of the business.

The question was also posed to the Comparison Group.

7.4.6 Networking

(Technium Companies Questionnaire Section: 4)
(Comparison Group Questionnaire Section: 3)

These questions were intended to investigate the intensity and geography of networking activity and the networks within which companies are engaged. Companies were asked if they participated in the following types of networks, and if so, how often;

- West Wales Chamber of Commerce
- WAG/WDA Technology Events
- Regional sectoral fora
- Trade Associations
- Trade Exhibitions
- Informal Sales Networks
- Informal R&D Networks
- Regional Partnerships (e.g. City and County)

They were also asked whether their networking encompassed other relationships with other technology companies (large and small), potential financers/partners and other organisations. Technium companies were asked whether and how often they networked with other companies from the Centres. A standardised scale regarding frequency of interactions was provided in order to ensure consistency between responses.

This section aimed not only to identify important networks and relationships within Technium, but to provide a picture of the overall intensity and nature of networking by all the companies in the survey

7.4.7 Financing and Support

(Technium Companies Questionnaire Sections: 5 and 6)
(Comparison Group Questionnaire Sections: 4 and 5)

Financing

Companies were asked where their initial funding originated from and whether they had subsequently attracted further investment. This was to determine whether there was any 'grant dependence' amongst Technium companies and how success rates compare for attracting further investment. It is worth noting, however, that while many types of public support are indicative of grant dependence, some schemes are highly competitive and could provide an indication of positive aspects of the business (e.g. KTP - innovation or RSA - job creation).

With regard to Technium companies it was also asked whether Technium had (directly or indirectly) assisted companies in attracting finance.

Support

The survey aimed to establish whether Technium companies are more likely to seek/receive support for their development, and where from the following this would be obtained:

- **Start-up support** – e.g. business creation or inward investment assistance
- **Financing Advice** – providing information/assistance in obtaining finance
- **Financing** – in terms of cash or other equivalent support e.g. RSA
- **Legal Advice** – such as assistance in management of IP
- **HR Support** – e.g. assistance in recruiting staff/training etc.
- **Marketing** – such as trade missions, market surveys/studies etc.
- **Other support** – which does not fall within the above categories

In the case of Technium companies, it was asked whether the Technium support services had assisted in accessing this support.

7.4.8 Technium Support

(Technium Companies Questionnaire Section: 7)

Expectations, Experience and Added-Value?

The 'Technium Support' section of the survey was conducted solely amongst Technium companies, and attempted to elicit information on;

- Support expected by Technium companies prior to their establishment in the Centres
- Experience of the support subsequently found by Technium companies in the Centres
- Whether the support available had added value to the companies

Responses were sought in respect of each aspect of business support with which Technium aims to assist companies, namely;

- Business Operations
- Developing Collaborations (Industrial)
- Developing Collaborations (Academic)
- Marketing / Analysing Markets
- Management
- Accessing Facilities
- Attracting Finance

Overall Impact and Experience

The section also examined the overall experience and effect on the companies of Technium and its support, asking companies whether the Technium has helped in the development of their business to date and if they expected Technium to have an impact in the future. The survey offered the entire spectrum of possible responses ranging from 'very positive' through to 'very negative'.

Companies were asked what their plans would have been in the absence of Technium: whether they would have established themselves in the same timescale; and whether it would have still been in Wales. This was done to assess the additionality of the Technium initiative. This issue has been approached in a similar manner in studies such as that by Luger and Goldstein (1991) in the US.

The final questions relating to Technium support asked for comments on the current level of support and facilities, and how they could be improved and extended.

7.5 Key Questions

The above has described how the surveys and interviews were developed to capture a comprehensive picture of Technium and its companies, to be used as a basis for development of an understanding of the initiative and to make comparison with companies outside. The findings are analysed in following sections against a set of questions which emerge in light of the discussion of Chapters 2 to 5. These can be summarised as:

Question 1: Are Technium companies predominantly spin-outs from academia?
Is Technium, as Cooke and Clifton (2005) suggest, significantly reliant upon the productivity of academia to produce spin-out companies? Otherwise, from where do Technium companies originate? Also, who are the founders behind Technium companies?

Question 2: Do Technium companies grow faster than those outside?
The core aim of Technium is to develop knowledge-based enterprises that deliver wealth and employment opportunities to the region (Technium 2005). Is Technium achieving this and how does the performance of companies supported by the initiative compare to those outside the Centres?

Question 3: Are Technium companies more intense innovators?
Abbey et al. (2007) described the role of Technium in encouraging innovation, though does this manifest itself in improved performance compared to companies in the wider community? Furthermore, do Technium companies exhibit greater investment in inputs to the innovation process and do they produce greater outputs?

Question 4: Are Technium companies more engaged in networking and collaboration?
As described in Chapter 2, networking and collaboration are of the utmost importance to foster innovation (Porter and Ketels 2003). Does Technium assist in such activity, and more importantly does this support result in companies which exhibit greater collaboration and networking?

Question 5: At the firm level what are perceived impacts of Technium and how the initiative could be improved?
Technium is described as offering a range of support to companies (Technium 1999, 2005), though does the support available meet the expectations of companies, and does it have an impact? Furthermore, in light of such considerations, how could the initiative be developed so as to create greater/further impact?

Ist Wales vorsprung durch Technium? – A Sub-Regional Innovation System?

The second part of the analysis considers the operations and performance of Technium and its companies against the characteristics of a 'Sub-Regional Innovation System' as proposed by Abbey et al. (2007). While Technium would only be a part of such a system, this perspective of the initiative provided by the surveys and interviews provides a unique opportunity to explore what role, if any, Technium plays in such a system. Though many concepts, such as linkages with large firms and universities overlap with the earlier questions this discussion is made specifically in the context of Innovation Systems.

7.6 Knowledge Enterprise in Technium - Findings

Data Collection – Technium Companies

A total of 22 Technium companies assisted in the survey, completing questionnaires and participating in interviews. This represents a response rate of 96% of companies approached and includes 90% companies at Technium Swansea, Technium Digital and Technium Sustainable Technologies[36]. One company declined to participate, citing concern over providing confidential information. This was despite assurances information would only be used in a purely aggregated manner and no company specific information would be passed to any third party.

Data Collection – Comparison Group Companies

130 e-forms were sent out to individual companies with 28 returned as undeliverable by mail systems. This represented a 'bounce rate' of 22%, which is similar to the experience of others using surveys using email, such as Sheehan and Hoy (1999).

A total of 27 comparison group forms were returned, 25 of them sufficiently completed for use in the survey. Though this sample is small it is comparable with the number of Technium companies surveyed. The level of response to a mail survey of 20-30% is in keeping with the experience of other studies (NBIA 2003), though is encouraging in light of the fact that that unsolicited email (that makes it through any filters) has a 'open rate' of around 30% (MailChimp 2007). An email thanking each of the respondents was sent upon receipt of the completed form.

For certain aspects of the survey, where publicly available information could be used the wider group of all IP Wales assisted companies was considered. This was done to provide a larger sample and identify broader trends for comparison with the cohort of Technium companies. Where this is the case it is highlighted in the following sections.

[36] Those not included are companies that could not supply sufficient information within the timescale of the research, along with the case of the company described

Results and Discussion

The following sections describe the findings of each of the aspects of the survey, combining the questionnaire results with the feedback received from the individual Technium company interviews. Sections 7.6.1 to 7.6.8 present the findings relating to high level issues, comparing with the Comparison Group where possible. Section 7.6.9 describes the experiences of Technium companies in regard to various aspects of the support offered, along with the overall company perceptions of Technium and how it could be improved. Sections 7.7 and 7.8 provide discussion of these findings in the context of the questions described in section 7.5 and of a Sub-Regional Innovation System.

7.6.1 Enterprise Development

Entrepreneurship

Of the 23 respondent companies only six reported to have had origins as a spin-out from an academic institution. Inward investors represent almost as many companies, while the majority class themselves as entrepreneurs or SMEs. In fact, as will be shown later, the employment levels of most businesses in the latter two categories could be included in the 'micro business' subset of the small enterprises definition, while the spin-outs themselves are a specific subset of SMEs. Fig. 7.3 shows the breakdown of business type amongst the Technium companies.

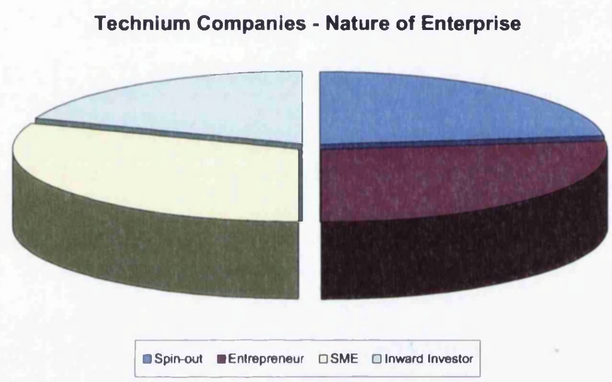

Fig. 7.3 Technium Companies by type

However, while the number of spin-outs is relatively low a much greater number of companies reported that they had founders who had originated from academia as shown in Fig.7.4. Over half (14) respondents stated founders included those with an academic background. The survey did not explore if these founders were teaching staff, researchers, technicians etc. or whether their involvement in academia was ongoing or in the past. However, this does indicate an involvement of the academic population in enterprise beyond formal spin-out activity.

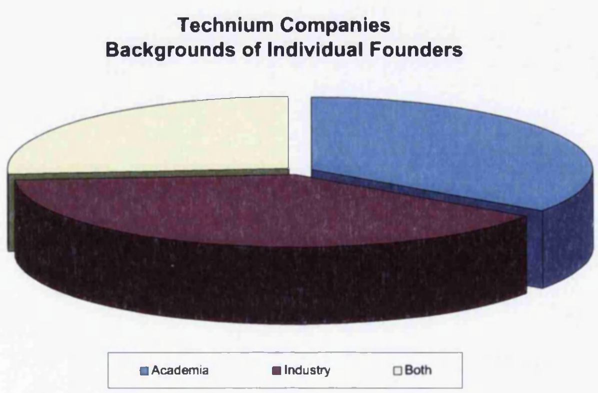

Fig. 7.4 Technium Companies - Background of Individual Founders

Business Development – Growth and Operations

Of the 23 Technium and 25 comparison group respondents, turnover figures were provided by 16 and 18 companies respectively. While certain information regarding turnover is available from Companies House for the other companies it was decided to base the analysis on the responses received.

Despite the average age of Technium companies (~9 years) being lower than that of Comparison Group companies (~10 years), it was found that during the period studied (2001-2007) Technium companies had a higher average turnover of £586,103, compared to an average of £334,900 amongst the Comparison Group companies. While this demonstrates that Technium companies are bigger it does not show whether they are growing faster.

Fig. 7.5 presents the average turnover growth of Technium and Comparison Group companies. Encouragingly the turnover of both groups of companies has grown throughout the period studied. However, it is clear that the growth rate of Technium Group of companies has consistently outperformed the Comparison Group. While the rapid increase towards the end of the period indicates an apparent surge in growth of Technium companies it simply serves as an indication of the sensitivity in such analysis of small groups. Much of the growth in turnover amongst the Technium companies during the final two years considered relates to one company, exhibiting massive growth. Despite this, even when this company is excluded from the analysis (shown by the green plot in Fig.7.5) it can be seen that growth rates amongst the Technium cohort remain significantly stronger than the Comparison Group. However, excluding companies such as this from the analysis misses the point of Technium. The development of high-growth companies (or 'gazelles') is part of the ambition to create clusters of innovative companies in the wider community.

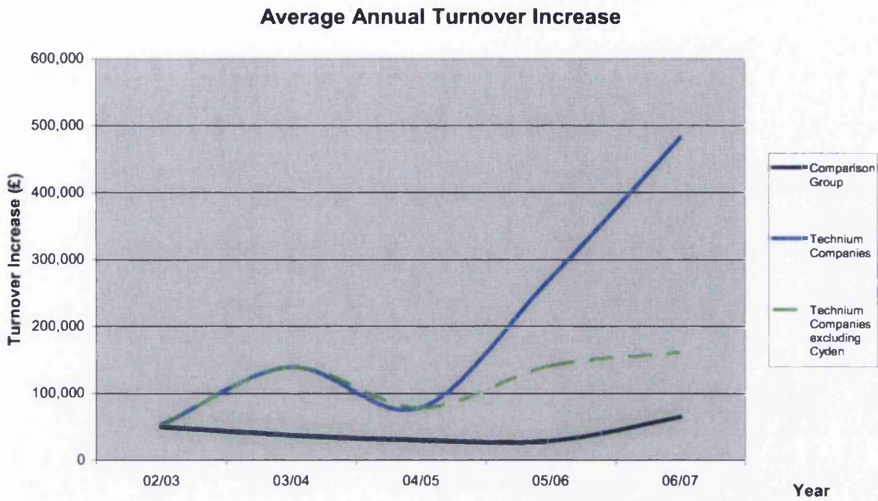

Fig. 7.5 Average Annual Turnover Increases

While the overall picture for each cohort is provided by the analysis shown in Fig.7.5, the question remains as to how this relates to the individual companies. In this regard, a greater level of variance in turnover throughout the period was found amongst Technium companies, suggesting a greater spread in size of companies, as presented in Fig. 7.6. This was particularly prominent towards the end of the period where the success of certain firms increased the standard deviation markedly – again an effect amongst the data of the 'gazelles'.

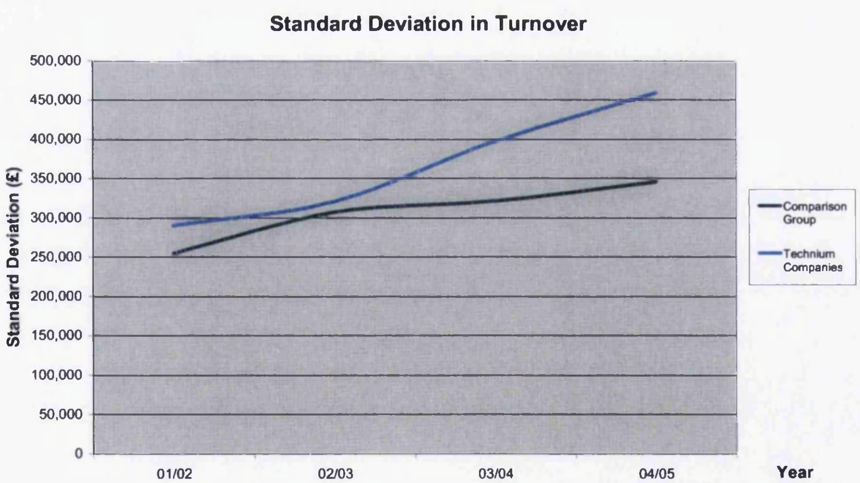

Fig. 7.6 Standard Deviation of Turnover in Company Groups

Another dimension to the consideration of growth amongst the two cohorts of companies is that it is easier for smaller companies to achieve high percentage growth rates than their larger counterparts. Such logic would suggest Technium companies would be disadvantaged in comparison with the Control Group due to their higher average turnover. Fig. 7.5 would suggest otherwise at the cohort level, which is reflected at the company level in Fig. 7.7, which presents the average turnover growth of individual firms during the period against their turnover weighting.

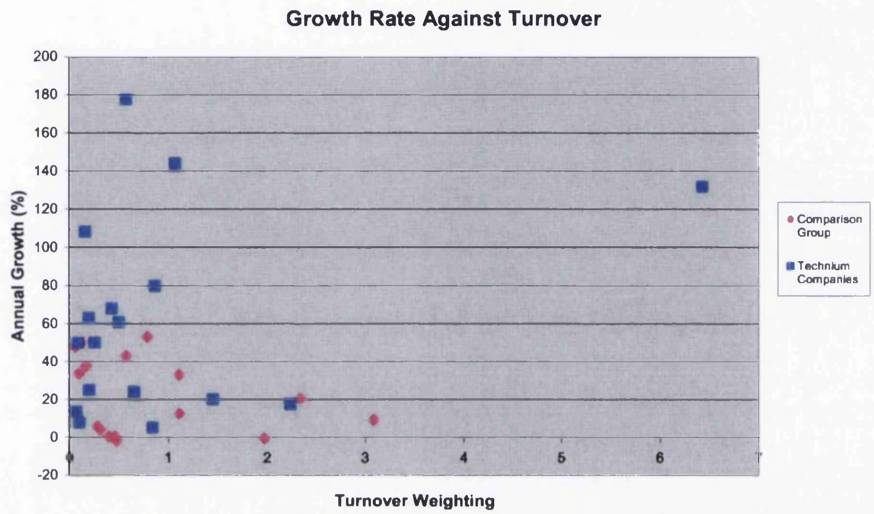

Fig. 7.7 Average Annual Growth Rate against Turnover Weighting

Using a Pearson test, no statistical correlation was found between the size of company and its turnover growth[37]. While no correlation was found between these factors a relationship was found between the past experience of entrepreneurs in Technium and the growth of the companies with which they are involved.

Serial Entrepreneurship

The survey had questioned how many companies the founders had been involved with previously. This was asked to identify whether Technium was attracting 'serial-entrepreneurs'. It was found that many of the companies had founders with prior involvement in other businesses. 53% of respondents reported involvement with up to six companies previously. Excluding 'Inward Investing' companies (which it can be argued face different challenges) this figure rises to 77%. Fig.7.8 presents annual turnover growth against previous experience of founders. Though the sample is limited, as it includes only those companies who had responded fully to both turnover

[37] results of the Pearson test were 0.27 and 0.3 for Technium and Comparison Groups respectively

and previous experience, a positive correlation between the two factors can be seen. Applying a Pearson test produces a correlation factor of 0.6 suggesting that positive correlation exists, though is not necessarily linear. Further exploration would require additional data to better understand the strength and nature of this relationship.

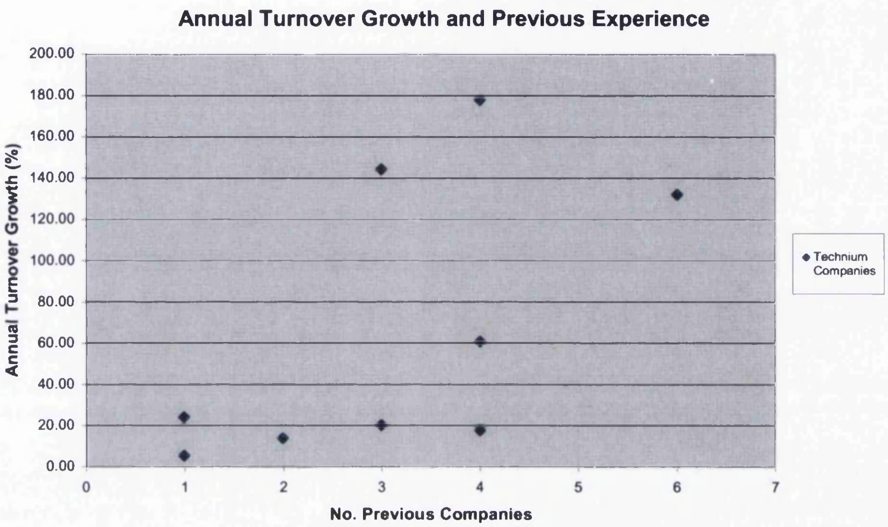

Fig. 7.8 Turnover Growth and Previous Experience – Technium Companies

7.6.2 Employment

The employment impact of Technium has been described earlier in Chapter 6. This included an assessment of the employment impacts within and outside Technium, and during the operational and construction phases. The survey element of the study aimed to compare how the employment within Technium companies compared with that of other firms.

Taking averages for the two groups of companies shows an average firm size of 8.5 and 10.52 Full Time Equivalents (FTEs) for the Technium and Comparison groups respectively. However, this is skewed by one company in the Technium Group and a couple of relatively large companies in the Comparison Group. The extent of this skew is demonstrated by their respective standard deviations of 8.4 and 14.6 FTEs, which in the case of the Comparison Group is much greater than the average value. This again highlights the difficulty in comparing small groups. Comparing the average employment amongst the remaining firms gives an average of 7.39 and 6 FTEs for the Technium and Comparison groups.

At a much simpler level, comparison of change in employment amongst firms during the survey period presents a marked difference between companies in each of the groups. As presented in Fig.7.9 it was found that employment in 42% of Comparison Group companies increased, while employment in the same proportion remained unchanged and 16% of companies saw a decrease in employment. Technium companies on the other hand saw all bar one enjoy an increase in employment during the period. Employment in the remaining Technium company remained unchanged during the period.

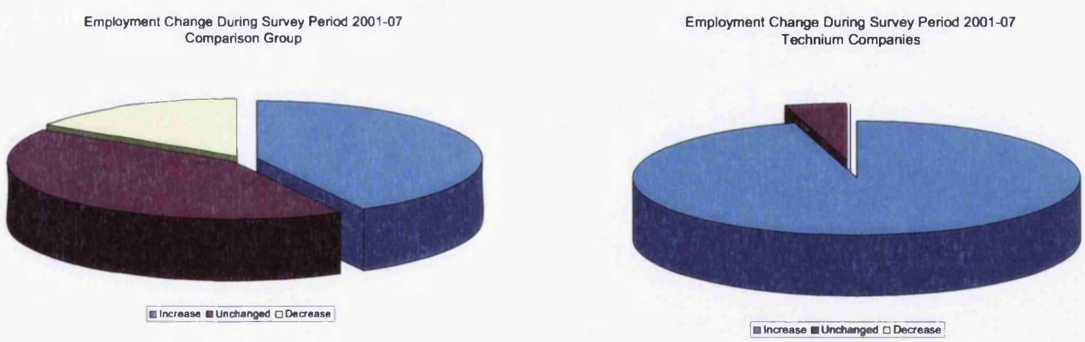

Fig. 7.9 Employment changes in Technium and Comparison Group companies during survey period 2001-2007

7.6.3 Graduate Skills

While all companies, in both the Technium and Comparison Groups felt graduate skills were important some commented that they had difficulty in recruiting those from disciplines including sciences and engineering. One respondent also stated that the company had difficulty in recruiting "*...graduates who can read and write in recognisable English*".

A significant percentage of companies from both Groups employ graduates, though while all Technium Group companies employed graduates, 15% of Control Group companies reported to employ none. Each of the companies with no graduates was small, with no more than 3 employees in total. The proportion of graduates within companies varies significantly between the two groups. On average just under 50% of employees in Comparison Group companies were graduates, compared to over 80% of those employed in Technium (Fig.7.10).

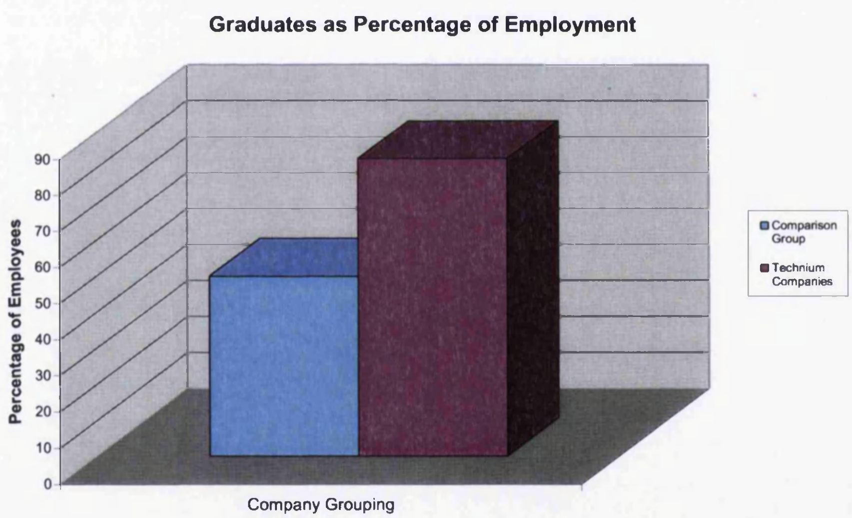

Fig. 7.10 Average Graduate Employment as Proportion of Total Employment

The difference in graduate employment is equally marked in consideration of the number of graduates within each company. Fig.7.11 illustrates that on average Technium companies employ 6 graduates, compared to 3 amongst the Comparison Group companies (considering only those Comparison Group companies with graduates employed).

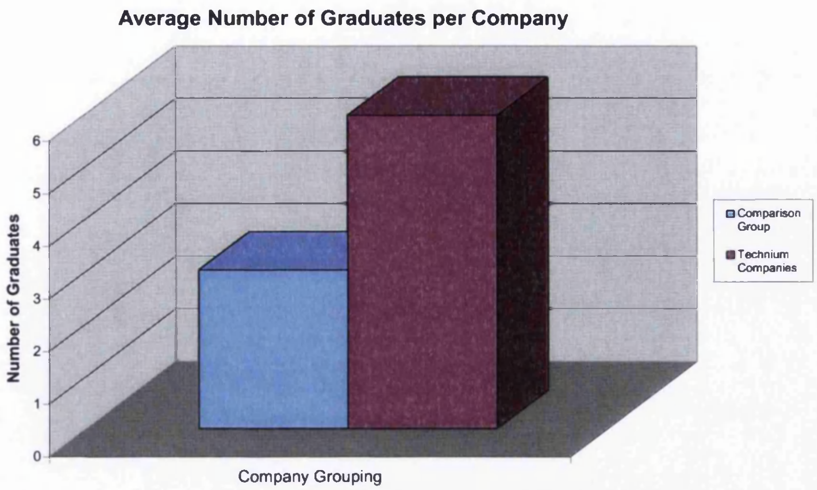

Fig. 7.11 Average Number of Graduates per company

The most prevalent graduate skills in both Comparison and Technium Groups relate to the Sciences and Engineering. This is perhaps unsurprising considering the types of companies involved. Fig.7.12 shows the breakdown for the Technium Group, where interestingly only 19% of companies claim graduates who have undertaken study relating to 'business'. The relatively strong showing for 'other' (claimed by 43% of Technium companies) relates to a range of disciplines and features strongly amongst companies with a creative focus such as media or graphic design.

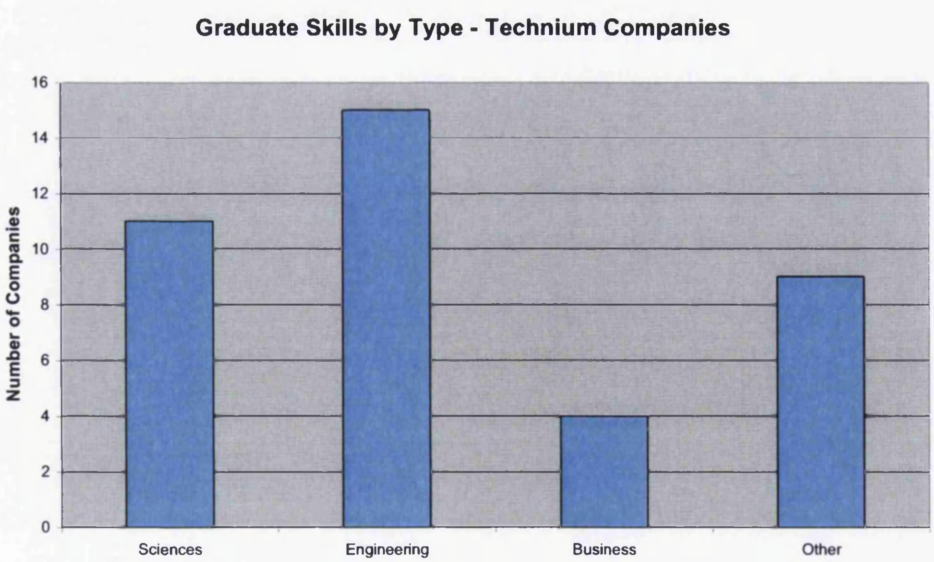

Fig. 7.12 Graduate Skills by Type – Technium Companies

7.6.4 Innovation Activity and Intensity

In order to compare 'inputs' to innovation, companies were asked what proportion of their staff were engaged in R&D or innovation (specifically the development of new goods/services). Fig.7.13 presents the finding that companies in Technium, on average, had more of their employees engaged in innovation (74% compared to 48% amongst the Comparison Group companies). The standard deviation for both Groups was the same at ~ 28.5%, suggesting that this higher proportion of employees engaged in innovation is a trend across Technium and not an effect of some companies having a particularly high intensity.

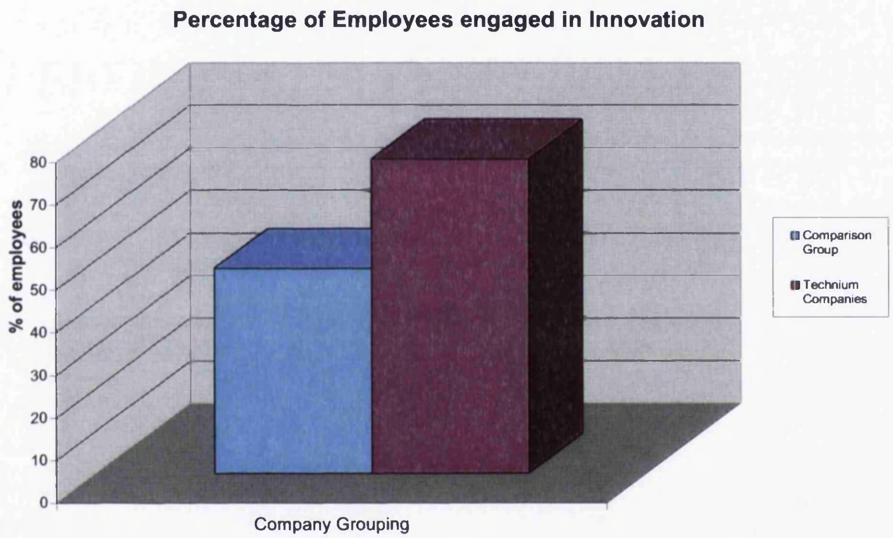

Fig. 7.13 Average percentage of company employees engaged in Innovation

The second consideration of innovation intensity focused on the 'intermediate products' of innovation – Intellectual Property (IP). The first strand of this enquiry was to ask companies what types of IP they create. As the Comparison Group of companies were assisted by IP Wales it can be assumed that they have at least a basic awareness and understanding of IP[38]. This was reflected in the responses where ~80% of respondents from both Groups claimed to generate IP[39].

Fig.7.14 presents the responses of the breakdown by IP type for the Comparison and Technium Groups:

[38] IP Wales was recognised by the World Intellectual Property Organisation as an example of best practice in creating awareness of IP amongst SMEs assisted, therefore this assumption can be considered robust
[39] The precise figures for the Technium and Comparison Groups were 83% and 76% respectively

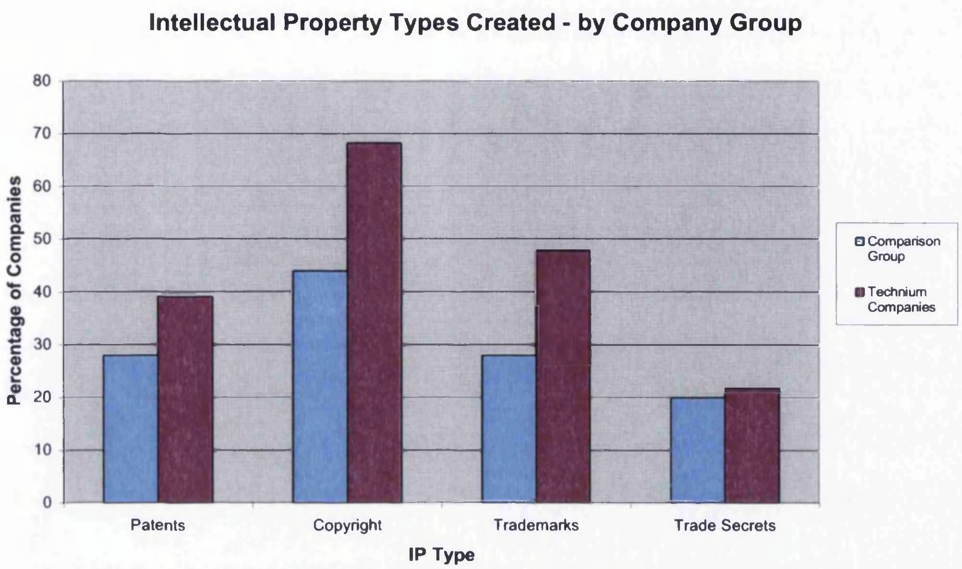

Fig.7.14 IP Types created – by Company Group

It can be seen that proportionately more Technium companies claim to generate each type of IP. From the nature of the support provided by IP Wales it would be assumed that there would be a strong showing from the Comparison Group, particularly in regard to patents and trademarks, for which the initiative provided financial assistance. The exception where the two groups have similar propensities to create is 'trade secrets'. Amongst the Technium Group the companies providing this response were mainly the 'inward investor' companies.

Though the above presents the types of IP which companies claim to create, it remains to be seen if this correlates with outputs. As described in Chapter 4, intangible assets such as IP are difficult to quantify and compare, especially in the case of copyright and trade secrets – the latter as its name suggests, being particularly difficult, if not impossible, to understand.

Patents are a traditional proxy and used together with other indices such as the innovation 'outputs' discussed later provide an interesting measure. However, not all companies in the Groups studied generated IP in the form of patents. In fact, holdings were only found for four companies in each of the Groups. This is not to say that the companies are not, as they claim, protecting IP through patenting, as filings may have been made recently and are not yet published or granted. This is supported by the finding that of the holdings discovered, all of the Technium Group patents were filed since 2000 (as would be expected considering when most of the companies were established), as were 60% of the patent holdings of the Comparison Group[40].

In order to extend the analysis the full Comparison Group was revisited to include companies that were not contactable or did not respond to the questionnaire. Using patent office records, holdings of all company holdings post 2000 were recorded. The 2000 cut-off date was used to define a period comparable with the activities of Technium companies. This provided a sample of 9 Technium and 23 Comparison Group companies with patent holdings. Fig.7.15 presents the average and maximum patent holdings by companies of these two Groups. It can be seen that Technium companies (those which have patents it must be noted) hold on average more, though both Groups have a relatively high standard deviation[41] reflecting a mix of companies with many and others with few patents. The largest Technium company patent portfolio contained 11 patents while the most significant portfolio amongst the Comparison Group contained 8. Holdings of these sizes indicate a strategic approach to IP management.

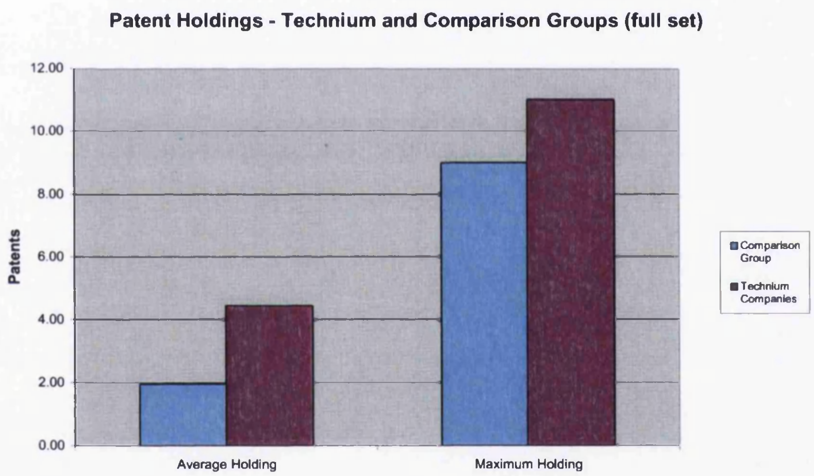

Fig. 7.15 Patent Holdings of Technium and Comparison Group Companies

Another finding from analysis of these holdings relates to the number of other patents that cite patents within these groups. As described in earlier in the Chapter, the citing of one patent by another is regarded as an indicator of its value. While relatively few patents were cited by others[42] it was found that Technium company patents were almost twice as likely to be cited (30% compared to 15.5%).

[40] It is worth noting that all Comparison Group patents prior to 2000 relate to a single company
[41] The standard deviation for average patent holdings is 2.1 and 3.6 for Comparison and Technium Group companies respectively
[42] A patent is more likely to be cited as time passes and technology advances

To investigate the 'outputs' of innovation, companies were asked how many new products and/or services they had recently introduced. As many of the companies in Technium were start-ups this analysis focused on the most recent two years when they would be most developed. Fig.7.16 shows that a greater proportion of Technium companies introduced new products and/or services during the past two years. However, this information does not cast light upon what proportion of sales related to these products, analysis of which would require further study and additional information. The apparent slight closing of the gap in the second year is not possible to interpret without a longer time series.

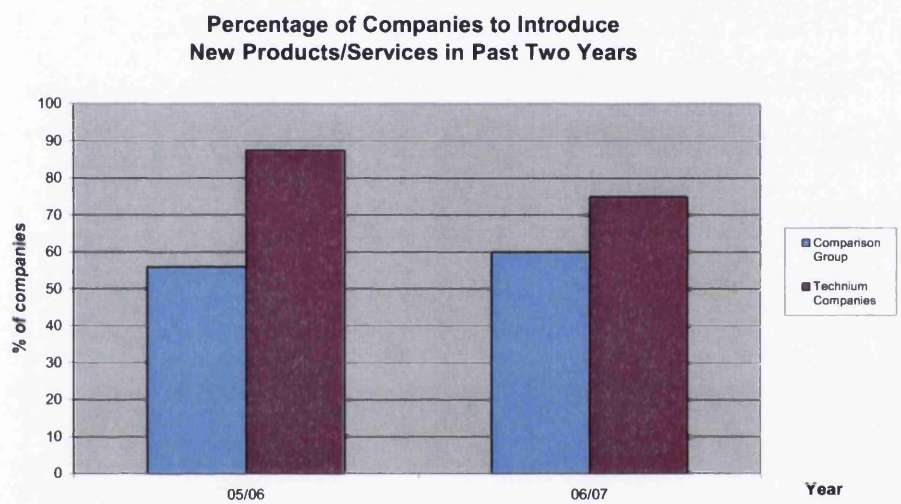

Fig. 7.16 Percentage of Companies introducing New Products/Services during the past two years

7.6.5 Innovation Drivers

The reasons for firms' innovation was also investigated. Fig.7.17 shows the proportion of companies from each Group that recognised four drivers of innovation. Overall, Technium companies were most likely to cite these as being reasons for their engagement in innovation. It also appears that Technium companies are more likely to consider their innovation activity as being led by consideration of the market, while most Comparison Group companies see innovation as being led by in-house developments. While this analysis may provide more understanding of the 'recognised' rather than the 'actual' drivers of company innovation, it would at least indicate Technium companies are more aware of the 'market' than other companies.

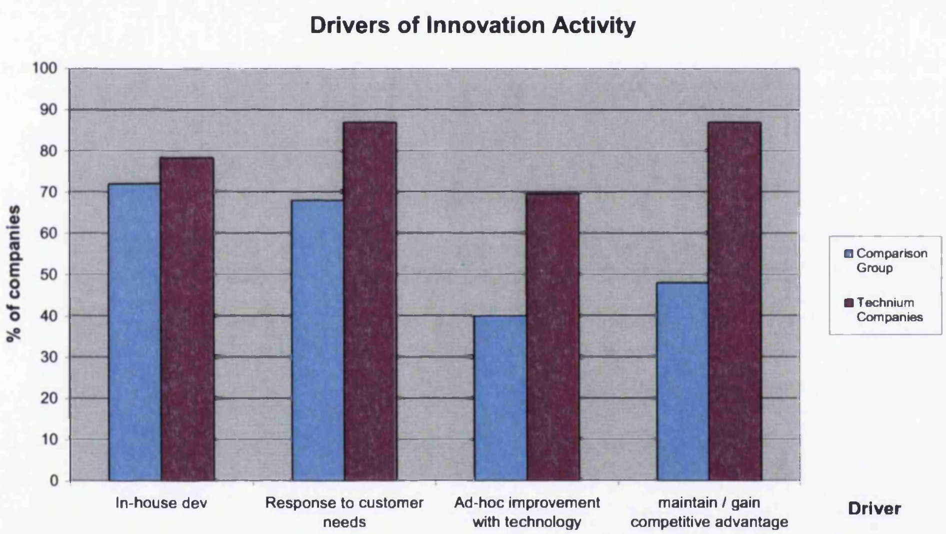

Fig. 7.17 Innovation Drivers by Company Group

7.6.6 Innovation Partnerships

Fig.7.18 presents the proportion of companies within each Group engaged in innovative partnerships by type of partner. It can be seen that the majority of Technium companies collaborate with one or more of their peers. The nature of these collaborations ranged from joint ventures, to consultancy and supplier relationships and ad-hoc technical advice. While the strength of individual linkages was not investigated, it suggests positive interaction amongst companies. As many of the companies are young, and relationships are new, the weaker linkages may develop over time. Interestingly, all 'Inward Investor' companies surveyed reported some form of collaboration with other Technium companies.

With regard to the other partner types, Technium companies were found to be more likely to be engaged with them in innovation, particularly for partners elsewhere in the world, including multinationals. While the presence of the 'Inward Investor' companies added to the global partnerships finding for Technium companies, even if these were excluded it would still represent 50% of firms, and significantly more than the 24% of Comparison Group companies.

The majority of Comparison Group partnerships were found to be with UK firms, and predominantly other SMEs. Engagement with other Welsh firms was found to be as likely as for Technium companies.

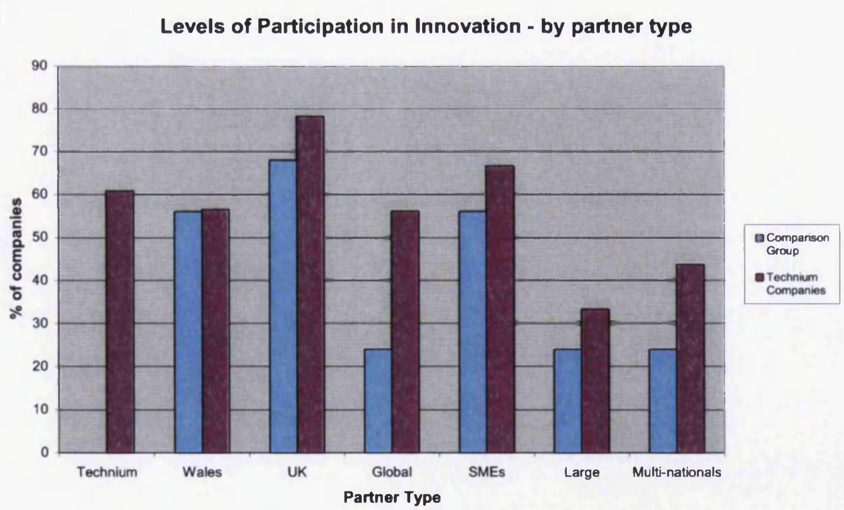

Fig. 7.18 Percentage of companies engaging in innovative partnerships – partner type

The greater prevalence of Technium companies to partner with other external agents was also reflected in the likelihood of having links with Welsh HEIs. Over 65% of the Technium Group had academic links, compared to 40% of the Comparison Group. The nature of these relationships ranged from research projects to student placements and use of consultancy.

7.6.7 Networking

Section 7.6.6 above described how Technium companies are more likely to be engaged in innovation with partners from different territories, it was also investigated how often companies networked in each of these territories.

Fig. 7.19 presents frequency of networking. It can be seen that Technium companies engage more often in global networks, which correlates with their increased engagement in innovation globally.

A t-test showed that while the greater frequency of networking by Technium companies in Wales was statistically significant, it was not so in regard to UK networking. However, in light of section 7.6.6 it can be argued that, despite the comparable levels of UK networking, either fewer Comparison Group companies are networking, or the networking is less productive as it results in fewer innovation collaborations. Two respondents did though highlight networking can sometimes be detrimental, one company citing they had lost a key member of staff, poached by another company he had met at a trade fair.

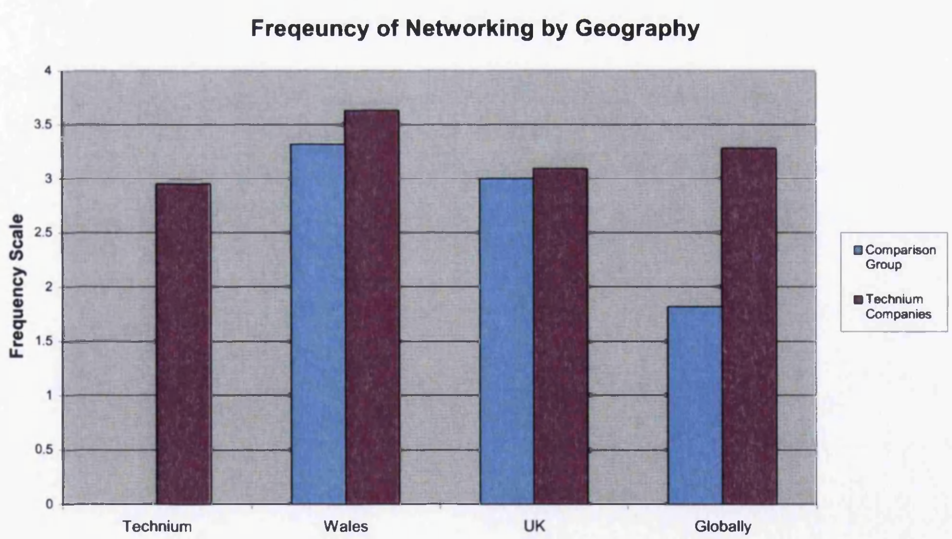

Fig. 7.19 Frequency of Networking by Territory

7.6.8 Financing and Support

Finance

The Technium Group of companies were asked the origins of their start-up funding. The majority of funding for 'Inward Investor' companies came from the parent organisation, though the other companies exhibited a mix of sources. Founders own funds were involved in each of these ranging from the entire investment to a small stake. Interestingly, the involvement of government grants is relatively low, with no more than 40% of initial funding in any company coming from this source, and the majority of company start-ups not including any grant funding at all. (Fig.7.20)

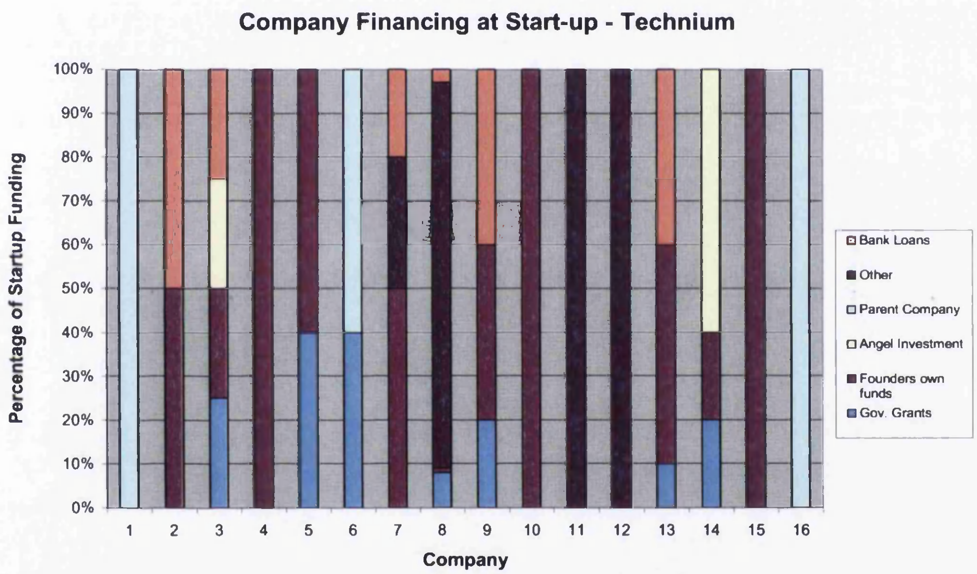

Fig. 7.20 Technium Companies – Funding at start-up by type

As Fig. 7.21 presents, the majority of both Technium and Comparison Group companies have been successful in accessing grant funding subsequent to start-up. While the proportion of Technium companies reporting attraction of grant or angel investment is not significantly higher than for the Comparison Group, proportionally more Technium companies have accessed funding from venture capitalists or commercial partners. However, the relatively small number of companies involved makes it hard to identify this as a broad or significant trend.

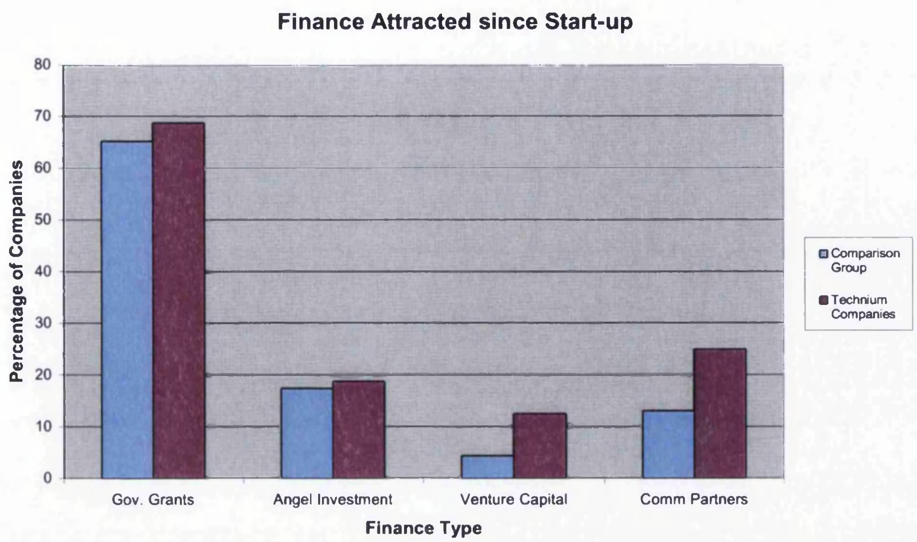

Fig. 7.21 Proportion of Companies Attracting Additional Finance by Type

Support

Figs. 7.22 and 7.23[43] present the proportion of Technium and Comparison Group companies accessing support by nature of support provided. It can be seen that the most common form of public sector support accessed, by both Technium and Comparison Group companies, relates to finance, legal and marketing. Overall, more Technium companies had accessed public sector assistance for the entire range of support types with the exception of 'start-up' support, which it could be argued predates the involvement of Technium with the business.

The role of the Technium managers was highlighted, with particularly proactive and supportive individuals receiving significant praise from the companies. It was understood by the companies that the staff could not be expert in all market sectors or aspects of business, but the Technium staff would always endeavour to solve problems and identify solutions, including access to support.

Types of public sector support accessed significantly by Technium companies that did not feature strongly for the Comparison Group were HR, Marketing and Finance. The HR support accessed by Technium companies was, in the main (60%), advice provided by Technium staff, while the rest came from programmes such as Graduate Opportunity (GO) Wales. The higher uptake of marketing support relates to a particularly high up take of assistance by Wales Trade International (now called International Business Wales) to Technium companies in the form of trade missions and consultancy.

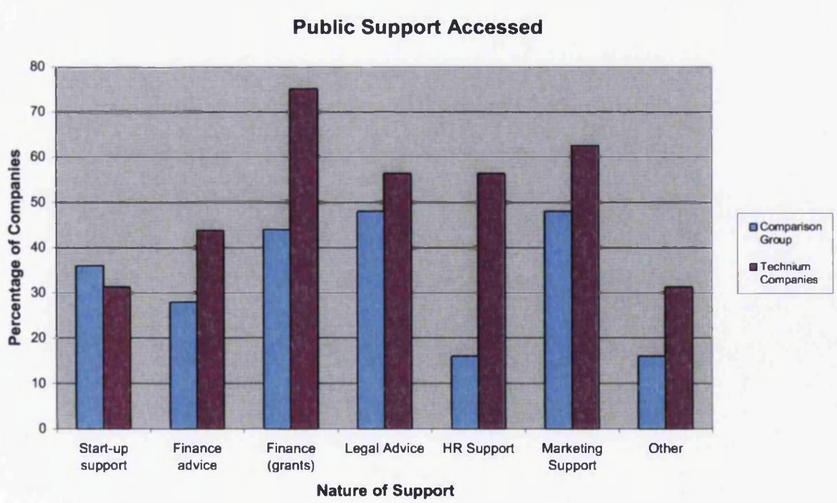

Fig. 7.22 Public Sector Support Accessed by Support Type

[43] N.B. Different Scales on vertical axes of graphs

The uptake of private sector support presents a much different picture, as shown in Fig.7.23. Uptake of all support types is lower than for public sector assistance. As private sector support is likely to involve greater cost, this may be a factor. The finance support received by both groups of companies came primarily from accountants and banks, while legal assistance was a mixture of solicitors and patent attorneys.

Comparison Group companies were more likely than their Technium counterparts to look to the private sector for assistance with finance, though the overall uptake by both groups is low compared to their use of public sector support. They were also found to be more likely to have accessed private sector HR support.

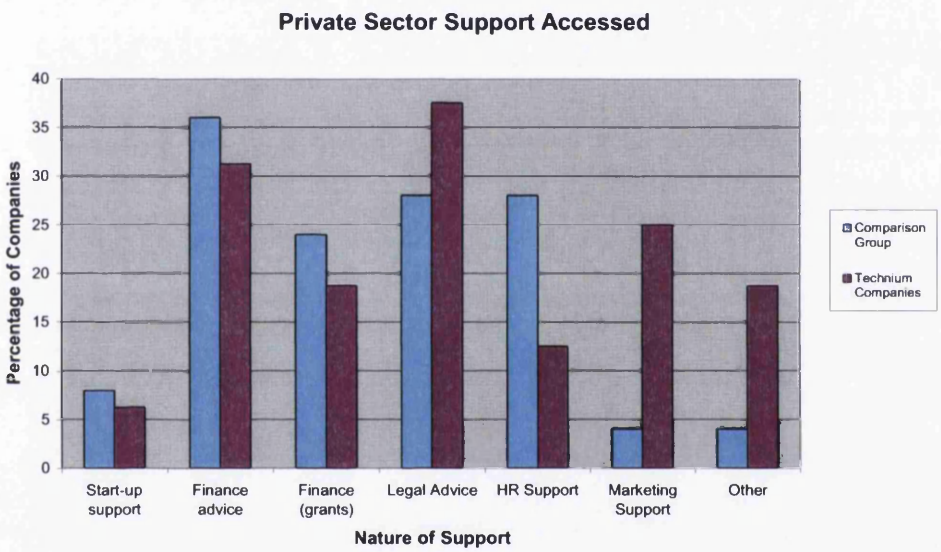

Fig. 7.23 Private Sector Support Accessed by Support Type

7.6.9 Technium Support

Expectations, Experience and Added-Value?

The support most expected by companies from Technium relates to accessing facilities and development of collaborations (particularly with academia), along with support of business operations. This reflects the core offerings Technium claims to offer (as presented in Fig. 5.1).

Business Operations

Many of the companies expected assistance with their day-to-day operations. From the interviews it was understood that many of the companies stating such expectations consider this to be provision of facilities and services such as a building receptionist, car parking, and telephony/Internet connectivity etc. It is therefore interesting that there were not more companies stating such expectations, though many considered such functions as standard. However, the fact that many more companies had 'found' such support available supports the argument that many companies did not initially consider the role of such assistance.

The number of companies finding such support added value equalled those expecting such support to be available. The interviews found that those companies which found the support available, but not adding value, cited various reasons. These included problems with the provision of car parking[44], the absence of a permanent receptionist presence at the reception of one Centre, and the belief that many of the offerings needed to be further developed. An example of such an offering was the reception function, where it was thought by some companies that the reception could provide a personalised response for enquiries directed to each company as an 'out-of-office' facility.

The importance of such basic operational support was highlighted by an anecdote from the Technium Swansea manager. Changing the time of mail collection from 3pm to 5pm resulted in one company economising £3-5k annually by not having to send parcels by courier. The business concerned works in the digital media sector and often required a fast turnaround for customers (often for the same or next working day) resulting in material not being ready by earlier in the afternoon. While much of their work can be conducted electronically, a significant amount still results in a form that requires conventional mail services.

[44] This was noted at Technium Digital, which is based on a University campus where car parking provision is restricted and at Technium Swansea where the development of 'SA1' has led to removal of a car park

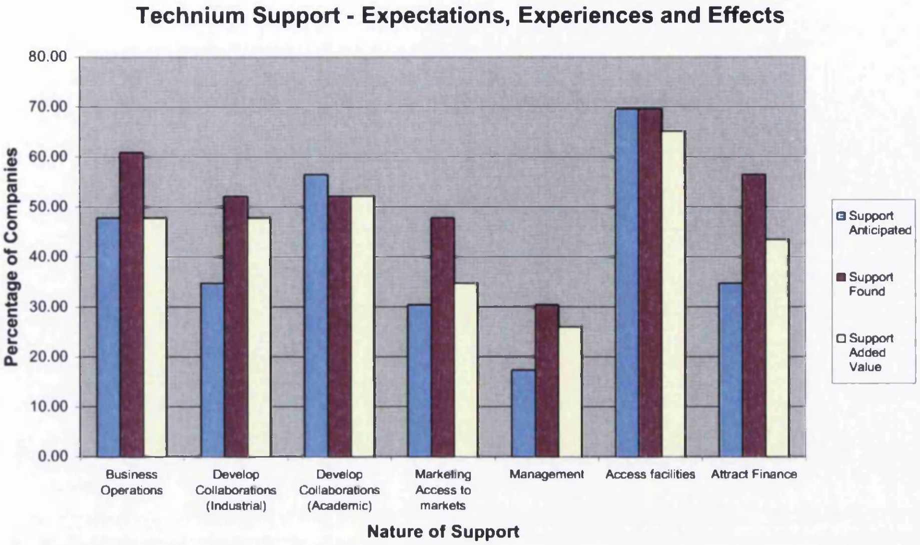

Fig. 7.24 Technium Support – Expectations, Experience and Effects[45]

Developing Collaborations

It was found that more companies had found Technium offered opportunities to develop industrial collaborations than had expected such support. Furthermore, the number stating this added value is almost equal to the number which found such support. The nature of such collaborations, including those between Technium companies described in section 7.6.6, are quite broad. Some of the most interesting collaborations involve the major partners of Technium. For example, one Technium company is already having a product manufactured for them at the Pencoed SONY plant[46], while others reported during the interviews that they too are in advanced dialogue with SONY regarding similar arrangements.

Slightly fewer companies found Technium helped in developing academic collaboration than had expected such assistance. Despite this, it is encouraging that the number of companies finding this support equals the number stating it added value, implying that where Technium is providing such support, it is to good effect.

As the level of academic collaborations developed with Technium assistance is lower than the 65% of Technium companies found to have links with academia, some linkages have clearly

[45] N.B. Scale runs to 80% to more clearly present differences between values
[46] The company concerned is TVonics, based at Technium Digital @ SONY and was not included in the survey as it had graduated. However, it is certainly worthy of further individual study

originated through channels other than Technium support. This is understandable, particularly in light of over half of company founders possessing some form of academic background and a high number of graduate employees[47].

Marketing and Management

More companies stated they had found marketing assistance than had been expecting it, and the interviews found that much of this support related to the WTI[48] Trade missions and consultancy described earlier in section 7.6.8. Many of those who felt the assistance had not added value, stated this was because the support would still have been available to them if they had not been in Technium. However, this withstanding, the uptake of such WTI support was higher than amongst the Comparison Group and the overall picture remains that more companies felt this had added value, than had expected such support in the first place.

Very few companies expected support in the management of their businesses (under 20%), though many found support available. From the interviews it is understood that these experiences generally relate to issues such as human resources where the Technium manager can assist.

Access to Facilities and Attracting Finance

The most expected type of support was access to facilities (both technical and non-technical) and the level of expectation was equalled by the number of companies finding such access. Some companies at Technium Sustainable Technologies did however find that access to the 'Solar Centre' facility was not as flexible as they had hoped. The most frequently used facilities were found to include reception areas and meeting rooms with all respondents regarded their quality as very good or excellent.

Over 40% of companies reported Technium had assisted in attracting finance. This represents more companies than had expected such support, though over 10% fewer than had found such support. The interviews found that companies who felt value had not been added thought that more would be done in opening doors to financiers. Some companies took a broad consideration of whether/how Technium had assisted in this respect. One company when interviewed responded, "*Sure it does, look at our website!*". The company owner explained how the "*image*" and "*prestige*" of Technium had given his company the stature to attract a group of American investors.

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[47] As presented in sections 7.6.1and 7.6.3
[48] Now part of International Business Wales (IBW) in DEIN

Overall Impact and Experience

Plan B?

As described in Chapter 6, the displacement, deadweight and additionality effects of projects and initiatives such as Technium are calculated at the programme level where the interrelations of efforts can be considered. However, it was found that the majority of companies would not have been established in Wales had Technium support not been available. This can be seen by combining the responses for 'not at all' and 'elsewhere' to represent 60% of the companies (as shown in Fig. 7.25). Along with the loss of the direct impact of these companies, this could have reduced the opportunities available to companies and other organisations with whom they partnered. Furthermore, the effect of other companies establishing later could also have resulted in loss of impact and opportunities during the delay[49].

Previous sections have described the differences in growth and innovation of Technium companies compared to companies in the wider community. Therefore, whether or not a particular company has established itself in Wales, their growth may well have been in line with that of the Comparison Group there would have been a net loss in terms of employment and innovation.

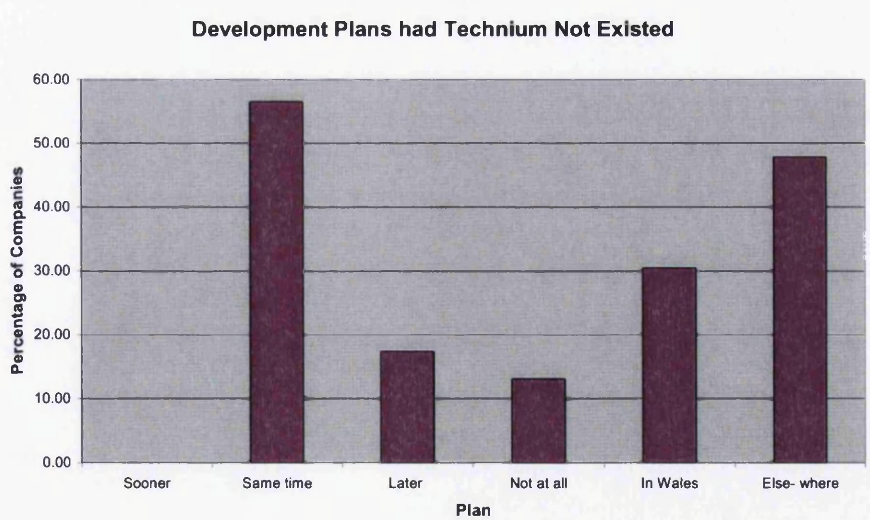

Fig. 7.25 Company plans had Technium not existed

[49] This is assuming that the founders and those involved in the company would have had less of an economic impact, engaging in substitute activity.

Perceived Impact of Technium

All companies surveyed believed Technium had made a 'Positive' or 'Very Positive' impact upon their business. Interestingly it was also found that those companies responding 'Very positive' were those based in Technium Swansea and included the company with particularly strong growth described in section 7.6.1.

With regard to the future impact almost all companies felt Technium would have a positive impact. One company felt Technium would not have any further effect, stating that the support offered focused mainly on companies at early stages of their development. This links in with some of the potential improvements suggested, which are described in the following section.

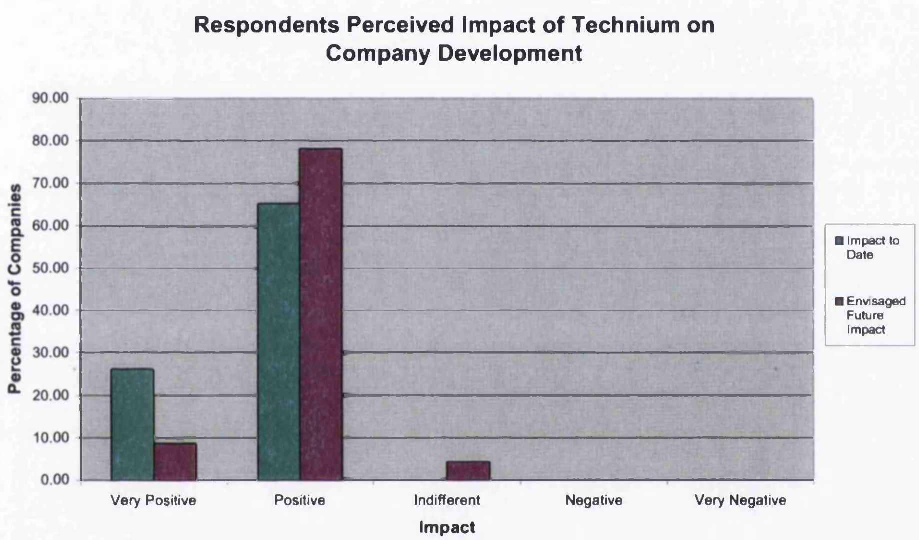

Fig. 7.26 Perceived Impact of Technium on company development

Potential Improvements

The surveys and interviews solicited feedback regarding how Technium and its support could be improved. Car parking was an issue raised at the Technium Swansea and Technium Digital sites Described below is a summary of this feedback:

Support

Many companies felt business support could be more focused and proactive. Particular interest was expressed in support and marketing development. Regular updates and meetings between companies and Technium managers were suggested, though it was acknowledged that the managers always made themselves available.

The importance of, and desire for, marketing support is reflected in the high uptake of this type of support by Technium companies. Typical of many comments provided in the interviews was; "*The guys here know their product and technology, maybe even the market they are targeting, but growing a business requires a different skill-set*". One company made the specific suggestion of developing or linking in with an existing mentoring organisation, though other respondents simply highlighted this as an area of need, rather than suggesting a specific solution.

With regard to other types of support the suggestion was made that arrangements could be made with private sector providers to provide Technium companies with improved support and preferential rates. It is understood that a new offering, the 'Technium Stakeholder' scheme, is being developed to achieve this.

Networking

During the interviews the absence of communal areas was highlighted by many respondents. This it was felt, led to a missed opportunity for company personnel to interact. While companies acknowledged that events such as workshops, seminars and social gatherings[50] provided opportunities for networking, these were not regular enough to provide day-to-day and casual interaction.

Additional Services and Facilities

Three companies based in Technium Digital expressed interest in workshop facilities for prototyping and product development. The firms explained how shared specialist facilities such as the virtual reality cave were a good idea, but these could be complemented by an environment for other types of development[51].

Some of the smaller companies also expressed interest in assistance with child-care arrangements. From the interviews it was clear that the idea of an on-site crèche was not being suggested, rather arrangements with a local nursery for example.

[50] Including a semi-disastrous inter-Centre football match organised by the author, which resulted in two friends sustaining serious (accidental) injuries
[51] One of the companies, though developing high-tech telecommunications solutions, had mixed concrete in their nicely furnished unit (as part of an experiment)!

7.7 Discussion

The following discussion describes how the findings relate to the questions posed in section 7.5.

Question 1: Are Technium companies predominantly spin-outs from academia?

Roughly a quarter of Technium companies originated as spin-outs representing an important, but far from dominant, proportion of companies. It has been shown that the population of Technium is made up of a mixture of company types including start-ups, SMEs and research off-shoots of inward investors. This casts doubt upon the validity of the argument by Cooke and Clifton (2005) that Technium is completely dependent upon academia for its supply of new enterprise.

The attraction of inward-investing R&D activities through promotion of knowledge spillovers reflects the findings of Cantwell and Piscitello (2005) of large companies developing activities to tap into localised knowledge spillovers. The attraction of investment by such companies reflects the need availability of higher level skills, R&D and other knowledge-based factors as described by Young et al. (1994). Furthermore, establishing value through R&D is a key motivation for MNEs in their FDI strategies (Wei 1999). This can be seen in the involvement of major partners such as Sony, 3M and IBM, who it has been shown are far more than suppliers to the initiative and actively engage with the other companies.

While a company's origins may not have been from an academic institution, strong links with academia were found. Along with collaboration in innovation (described below), it was observed that many Technium companies had founders with academic backgrounds and employed more graduates than Comparison Company firms. Providing such opportunities is a core benefit of Science Parks (Luger and Goldstein 1991). This addresses key WAG objectives of encouraging entrepreneurship and providing graduate opportunities to stem the 'brain drain' (WAG 2005b).

Question 2: Do Technium companies grow faster than those outside?

The Technium companies have higher turnovers than those in the Comparison Group, for companies with broadly similar numbers of employees. This is a typical attribute of young technology firms, as noted by Lewis (2001).

It was found that Technium companies have, on average, grown faster than their Comparison Group counterparts in both turnover and employment. While the rates of growth vary between

Technium companies, all had seen an increase in turnover; and all except one have experienced increases in staffing. Meanwhile, despite an overall upward trend for the Comparison Group the annual turnover growth was lower by a margin of over £100k per company compared to Technium.

This observation is in keeping with other studies such as that conducted by Löfsten and Lindelöf (2002), observing that companies in incubators grow more rapidly. Furthermore, by adding a Comparison Group to such analysis, rather than sector trends, it addresses limitations that Siegel et al. (2003) acknowledge in their own work examining UK science parks.

Interestingly though, no correlation was found between size of company and turnover growth, which runs contrary to the observation of Almus and Nerlinger (1999) that smaller firms grow faster than larger ones. While this may be a result of the relatively small cohorts involved in the study, this is curious due to the presence of other correlations suggested by similar studies. An example of such a correlation was that of the impact of entrepreneur past experience. This saw companies whose management had greatest experience exhibiting the strongest performance, thereby underlining quality of management as a key determinant of performance (Almus and Nerlinger 1999, Kakati 2003).

Question 3: Are Technium companies more intense innovators?

Technium companies were found to be more intense innovators than the Comparison Group in terms of inputs, intermediate products and outputs. The involvement of more staff in innovation together with a higher awareness of innovation and its drivers amongst Technium companies presents a greater intensity on the input side of the process. At the intermediate product level, though patenting only represents certain types of innovation, it was found that Technium companies with patents had larger portfolios than their Comparison Group counterparts. Furthermore, Technium company patents are more likely to be cited by other patents, indicating greater value (Harhoff et al. 1997). At the output side of innovation it was found that Technium companies have introduced significantly more new products and services over the past two years. These factors combine to demonstrate an overall greater intensity to innovate by Technium companies.

The correlation seen in this study of more intense innovation and greater employment growth reflects similar observations in previous studies (Henks 1996, Leadbeater 1999, Freel 2000).

Question 4: Are Technium companies more engaged in networking and collaboration?

The overall propensity for Technium companies to network and collaborate was found to be much higher than for the Comparison Group. While levels of 'local' networking in Wales and the UK were comparable between the two groups, the amount of collaboration by Technium companies with other organisations from these territories and elsewhere is much higher.

Technium companies also demonstrate a high level of engagement with academia with ~74% of companies collaborating with Welsh universities. This compares well with the UK survey conducted by UKSPA (2003) which found that on average, 41% of tenant companies had a link with a university or research institution, which in 90% of cases was a locally based institution. In this regard, the figure for the Comparison Group was also relatively high, standing at 40%, which is in keeping with the UKSPA figure.

The fact that 60% of Technium companies collaborate and innovate together demonstrates interaction between firms. Lewis (2001) found that Science Parks promoted the cross-fertilisation of ideas between companies. These collaborations were found to be not only small firms working together to share resources, but a whole myriad of interactions including development and manufacturing arrangements with one of Technium's global partners.

Question 5: At the firm level what are perceived impacts of Technium and how the initiative could be improved?

The positive perception of Technium by the companies it aims to support provides encouragement for the initiative. All companies in the survey felt Technium had made a positive impact on their business and almost all thought this contribution would continue into the future.

Many companies described how the prestige and reputation of Technium and its buildings had a positive influence on their companies in affecting how they are perceived by partners. While this may seem a frivolous issue, the importance of this effect has been noted in other studies (UKSPA 2003, Aernoudt 2004), as it assists companies to attract investment and custom by giving confidence to potential partners[52].

[52] One Technium company made the comment "Do you think people would take us as seriously trading from a shed on the Enterprise Zone", referring to an area of Swansea where many small firms are based

The most requested addition to Technium is development of further support in assist companies to grow, with a greater focus on individual company needs[53]. Since conducting the surveys and interviews DEIN has developed initiatives such as the High Growth Programme (HGP 2007), Knowledge Bank for Business and launched a major review of business support (Western Mail 2007), which it is intended will target, amongst others, Technium companies.

[53] This issue is also highlighted in the part of this study relating to the development of a regional Knowledge Economy Strategy described in Chapter 8

7.8 A Sub-Regional Innovation System?

In Chapter 5 the proposition of Abbey et al. 2007 that Technium is a component in a 'Sub-Regional Innovation System' was introduced, together with characteristics of what such a system would have. In light of the observations of the survey and interviews, are these characteristics exhibited in or by Technium? The following sections treat each of these characteristics in turn relating them to the case of Technium. This discussion draws upon the findings of the survey and interviews, together with the discussion and observations of earlier chapters. Where appropriate discussion of these characteristics has been grouped

7.8.1 Networking Characteristics

Characteristic 1: the creation of strong local knowledge networks, proximity being important for such desirable traits as 'imitation, emulation and reverse engineering'

Characteristic 4: SMEs in different technological areas having their own interactive networks (effectively, therefore, separate technological Innovation Systems interacting with the spatial Innovation Systems)

Characteristic 6: the importance of developing extra-regional links

The interaction shown between Technium companies and with other Welsh companies, both in terms of networking and actual collaboration, would indicate the development of such networks. This suggests that further study would be worthwhile to fully understand the interrelationships of these firms and to identify their role in any specific sector clusters, along the lines of that performed by Porter (1990) and Cooke et al. (2006).

The high propensity of Technium companies to network and collaborate throughout the UK and globally indicates companies are developing their own spatial and technological networks. The greater intensity of extra-regional engagement seen in Technium suggests the objective of the initiative to assist in networking is being met, validating the WAG policy to encourage such networks (Cooke 1998). While it could be argued that the networking performance is merely a characteristic of the firms themselves, the uptake of support such as marketing trade mission demonstrates public assistance in developing such links.

The Technium Stakeholder Programme[54] will see these networks complemented by a central network of interrelated actors. This will include patent attorneys, financiers, marketing consultants etc. formally drawing in a wider range of participants to develop a cluster (Porter 1990).

7.8.2 Academic and Skills Characteristics

Characteristic 2: the exploitation of the multi-disciplinary culture of a university

Characteristic 7: the importance of producing highly qualified workers to support the labour market.

As described in Chapter 5, Technium has linkages with various Schools at the University of Wales Swansea including Engineering, Law and the Institutes of Life Science and Advanced Telecommunications. These connections have been developed by the strategic involvement of the University in the development of Technium. The role played here by academia reflects that described in the work of Gunasekara (2006), where university management adapt, supporting the development of innovation systems bringing benefits to the region and the institution itself. Furthermore, the range of disciplines involved, often in the same Centre[55], represents a truly multi and interdisciplinary approach to academic support.

While the core activity of Technium may not appear to be the production of highly qualified workers, it is the core business of the academic partners involved in the initiative[56]. The resources of Higher Education are identified as a key component of Innovation Systems (Porter and Stern 1999) and the central role of academia in Technium would allow for the regional resources to be managed to maximum effect. However, it should be remembered that private sector training provision also requires consideration, as described for the automotive and electronics sectors in Wales by Cooke (1998).

[54] The Technium Stakeholder Programme is still under development with an invitation recently launched for expressions of interest by potential partners, Stakeholder Programme, www.technium.co.uk
[55] Technium Pembrokeshire for example is supported by expertise from the School of Law and the School of Engineering at the University of Wales Swansea
[56] Specific note should be made of the Masters in Business and Law course run by the School of Law at the University of Wales Swansea to develop a new wave of entrepreneurs has strong linkages with Technium. This provides an example of where the two agendas overlap

7.8.3 Technology and Innovation Characteristics

Characteristic 3: the avoidance of path-dependent overspecialisation in increasingly obsolete areas of technology

Characteristic 5: large corporations seeking to externalise part of their R&D functions to SMEs that can act as intermediaries with universities

The sectors targeted by Technium are those providing high-growth potential and offer a diversity which avoids overdependence on any particular technology or sector. Following the problems faced by the LG project (Phelps et al. 1998), Technium is a prime example of WAG avoiding placing 'all its eggs in one basket' (or one incubator, for a more appropriate metaphor).

Characteristic 5 could be interpreted to imply an 'outsourcing' of R&D by large corporations; though if interpreted more broadly, captures a phenomenon observed at various Centres of several large companies establishing R&D off-shoots within Technium. Vishay Siliconix, Laing O'Rourke and NPower Renewables are all examples of multinational corporations who have developed activity purely to engage with universities and the 'innovative milieu' amongst clusters of technology companies. The attraction of such enterprise ties in with the concept of 'upstream' innovation described by Cooke (1998), whereby universities and similar sources of knowledge generation are significant attractors.

This represents a new perspective on the old challenge of anchoring inward investment described by Young et al. (1994), by attracting the high-value activities of the company rather than the more basic.

8. Technium in the Broader Regional Context

Earlier Chapters have examined the impact of Technium and the contribution it is making to the development of a Knowledge Economy in the region. However, as discussed at the end of the previous Chapter, Technium is one component in a wider Regional Innovation System. The success of Technium, and the success of the region as a whole, depends upon how it, together with other components can work as an integrated system – providing something far greater than the sum of the parts. This Chapter focuses on an exercise undertaken in the region to address this specific issue.

As part of the Wales Spatial Plan planning process, the regions of Swansea Bay – Waterfront and Western Valleys, and Pembrokeshire came together in 2006 to develop an integrated Knowledge Economy strategy, in a territory that maps against the footprint of the Technium South West network. The research and strategy development work of this endeavour was undertaken by the author, supported by colleagues from the Department of Research and Innovation at Swansea University, whose assistance included facilitating workshop sessions and conducting interviews.

The first phase of the project, identifying the regional challenges to the Knowledge Economy, is described in this Chapter. As Technium is a cornerstone Knowledge Economy initiative in the region it relates to a range of Knowledge Economy issues. The following sections describe the development of the process and discussion of the challenges identified which relate to Technium

8.1 Identifying the Challenges

8.1.1. Introduction

In order to establish whether and how Technium is affecting the development of a regional Knowledge Economy, it is necessary to understand the challenges faced by the region. Acquiring this understanding was one of the stages in the development of a Knowledge Economy Strategy for the Swansea Bay – Waterfront and Western Valleys region, which is an integral part of the work being undertaken to create an integrated Wales Spatial Plan (introduced in Chapter 2). This research work was led by the author of this study, who:

- conducted background research,
- designed the interviews and surveys used,
- conducted interviews with stakeholders,
- analysed survey results and interview responses and
- authored documents used throughout the process including the Interim Report

This regional strategy development work was co-ordinated by the City and County of Swansea which invited the Knowledge Economy Research Group of Swansea University to undertake the research and facilitate the strategy development aspects of the effort. As described above, in this work the author took the role of conducting the background research, along with the design, execution and analysis of interviews and surveys. Interviews and workshops were planned and carried out with the support of colleagues, James Abbey, Louisa Huxtable and Gavin Bunting from the Knowledge Economy Research Group at the University of Wales Swansea. The approach adopted had parallels with other studies such as the EU Commission investigation of enterprise clusters and networks, which used a mixture of questionnaires and formal meetings amongst experts from the member states (EU 2003). As Technium is a cornerstone initiative of the Knowledge Economy in the region I took the opportunity to combine the access provided by this project to inform this study of Technium and vice-versa.

The methodology used in the identification of the challenges incorporated a range of qualitative techniques. These included focus groups, Delphi groups and individual interviews and were used at distinct phases of the research.

The diagram in Fig: 8.1, together with the following sections provides a description of the methodology developed by the author, with an overview of the processes adopted and materials used. An abridged overview of the methodology is included in Davies et al. 2007, Appendix 12.

Phase	1. A Common Starting Point	2. Identifying Challenges	3. Understanding Challenges	4. Prioritising Challenges	3. Agreeing Challenges
Stimulus Working Material	Spatial Plan Presentation	Key Questions	Key Questions	Challenges List	Interim Report
Process	Focus Group	Focus Group Delphi Group	Individual Interviews Delphi Group	Delphi Group Focus Group	Delphi Group

Fig: 8.1 Challenge Identification Plan

8.1.2 The Expert Group

It was clear that to identify the challenges properly, the Steering Group would need to incorporate individuals with specialist knowledge and expertise (experts) in the wider aspects of the Knowledge Economy. The Steering Group initially assembled consisted mainly of public sector representatives, thereby lacking the input of the other strands of the 'triple helix', presented in Chapter 3. To address this, industrialists from businesses, including hi-technology SMEs and multinational manufacturers, IP specialists, technology commercialisation experts and legal professionals joined the Steering Group to form a wider Expert Group. This ensured that the group was representative of all stakeholders and incorporated the range of expertise required to address the issues under consideration. The full membership of the Group is given in Appendix 13. This Group then participated in the five phases of activity, described in the following sections.

8.1.3 Phase 1: A common starting point and a shared goal

The first phase was to develop a common understanding of Knowledge Economy in the context of the strategies and vision of WAG, thus providing stimulus for Phase 2. Key to this phase was the mandate laid out in the Wales Spatial Plan (WAG 2004c), concerning the role of Technium in the development of the regional Knowledge Economy:

"*...The University, FE Colleges and Technia should embed the Knowledge Economy within the area...*"

(Wales Spatial Plan: WAG 2004c)

As many of the stakeholders were relatively unfamiliar with the concept of the Knowledge Economy a high-level overview was developed based upon the World Bank 'Pillars' Model described in Chapter 2. This was supplemented by quantitative evidence presenting the state of the region in terms of Human Capital, Innovation and Infrastructure to give an initial regional perspective. [57]

[57] The presentation provided to the Group is included in Appendix 14

8.1.4 Phase 2: Identifying the Challenges – 1st Expert Group Meeting

The first Expert Group meeting started with an initial presentation of the materials developed as part of Phase 1. This also provided opportunity to put into context the Knowledge Economy, making it relevant to each of the representatives and their organisations, for example;

Human Capital: While higher level skills may receive much attention, schools and colleges have an important role in developing the platform of basic skills and also supporting career path choices, particularly for science, technology, engineering and maths skills acquisition.
Innovation: Innovation is not simply 'invention' but a process that involves a wide range of expertise and support from disciplines such as marketing and management, along with resources such as finance, R&D facilities etc.
Infrastructure: Infrastructure is not only physical but 'soft', including networks and enterprise support

The Expert Group was broken down into a set of three Focus Groups: Human Capital (e.g. HE and FE representatives), Infrastructure (e.g. local authority and business support representatives) and Innovation (hi-tech SMEs and technology transfer representatives). Each group included public and private sector representation to provide balance. The Focus Groups each consisted of approximately eight members, which has been shown to be small enough to manage, while maintaining a group dynamic and allowing each member to be engaged (Greenbaum 2000). At least two members of each gender were included in each Focus Group. This provision was made as it has been shown to assist in preventing dominant personality behaviour (Fern 2001).

Focus Group members considered a set of questions asking them to discuss a number of themes, identifying challenges relating to Human Capital, Innovation and Infrastructure. Where there existed crossover in issues between Focus Groups they were discussed by both or all three Focus Groups.

A facilitator from the Knowledge Economy Research Group worked with each of the Focus Groups noting challenges and ensuring that each of the themes was covered during discussions. The facilitators also noted whatever consensus emerged within the Focus Group and reported this back to the full Expert Group for wider discussion (This part of the session was chaired by the City and County of Swansea). Further issues emerging from this wider discussion were recorded by the facilitators and discussed amongst the Expert Group in an open session.

8.1.5 Phase 3: Understanding Challenges – Stakeholder Interviews

The next phase of the process involved conducting interviews with the members of the Expert Group to explore their ideas regarding the issues and challenges identified. These were conducted by members of the Research Group working in pairs, who met regularly to plan and review interviews in order to ensure consistency in terms of questioning and information collection and recording. The main purpose of the interviews was to explore the thoughts of the individual members of the Expert Group with regard to the challenges identified during the first Expert Group meeting. To assist in the process, ensuring both coverage of all identified issues and consistency of information gathering, a template was developed for use by the interviewers. This template is included in Appendix 15.

The interviews, and the template, were structured around the three pillars of Human Capital, Innovation and Infrastructure and included specific questions relating to Technium. Questions relating to Technium included asking what links, if any, Technium had with the stakeholders or their organisations and how it could/should interact.

The semi-structured approach was adopted as it allowed in-depth discussion of specific issues while ensuring that each aspect of the interview was covered. The interviews were piloted amongst some of the more accessible members of the Expert Group prior to its wider use. Each interview lasted approximately one hour, depending on the time commitments of the interviewee and the depth to which they explored the issues. These individual interviews were conducted in anonymity from other Group members with combined results fed back to the experts as a Delphi Group so as to allow greatest possible freedom of expression and so that individuals (even of the same organisation) were unaware with whom they may or may not be agreeing. Two interviewers met with each stakeholder in order to ensure comprehensive records were kept and to provide consistency between interviews as interviewing pairs were mixed. These interviews were held at either the interviewee's place of work or a neutral location such as the University of Wales Swansea.

8.1.6 Phase 4: Prioritising the Challenges

The challenges identified and described through Delphi feedback rounds were passed anonymously to the members of the group for ranking. This was performed by use of an 'e-form' and required the group to make choices about the issues (avoiding for example simply ticking every box and thereby not ranking the issues). This form is included as appendix 16.

The object of this exercise, was not to develop a consensus of how the Expert Group as a whole prioritised certain challenges, but to highlight any commonalities or differences between how the challenges are perceived between types of stakeholder within the Expert Group.

The results were broken down, while preserving anonymity, into generic groupings of responses from 'Public', 'Private' and Education' sectors and presented to the whole Expert Group at the next meeting where the differences were discussed. These discussions were held amongst three Focus Groups that mixed public, private and education sectors. Moderators recorded these discussions to aid in the development of the Interim report.

8.1.7 Phase 5: Agreeing on the Problem – Interim Report

The final Phase was development of the 'Interim Report' which provided a consensus on the challenges which the Knowledge Economy strategy would need to address. An early draft version was circulated amongst the Expert Group, incorporating the findings of the stakeholder interviews. The challenges initially identified in the first Expert Group, along with those subsequently identified were presented in the Report together with quantitative evidence that supported or simply gave context to each challenge.

Feedback was solicited from the Expert Group in light of the findings of the stakeholder interviews and evidence provided by desk research. This resulted in a more advanced draft that was discussed at a subsequent Expert Group meeting. This advanced draft report collected the output of the phases described above together with the stimulus materials and information provided to the group. This made use of the stakeholders as a Delphi Group to allow free input while stimulating each member with the anonymous input of their peers. Following a final consultation phase a finalised report was developed which was used to support the remainder of the strategy development process.

8.2 Meeting and Interview Observations

During the meetings it was found that while certain personalities did not become dominant, there were certainly some which were adept and confident at putting forward their opinions. Addressing this challenge, the facilitators were able to successfully chair the Focus Groups, soliciting views and from all members on each of the discussion points. For the meeting following the individual interviews, a confidential aide-memoire was provided to each of the facilitators allowing them to anonymously prompt the Focus Group with points raised by members during the interviews.

The Individual Interviews passed off without any of the difficulties which Marshall and Rossman (1999) identify as risks in what are termed 'Elite Interviews', despite many of the representatives having particularly busy schedules.

One issue that arose during the process related to the Delphi responses provided by the Expert Group. Following the merger of various bodies into DEIN[58], many public sector representatives work closely. One senior representative decided to 'co-ordinate' many of the Public Sector responses, providing combined feedback. As this would remove the benefits of the anonymous Delphi approach the representative was thanked for his thought, and the various Public Sector representatives were contacted independently[59]. In particular, the research aimed to solicit input from the strategic, managerial and operational layers of the various stakeholders, which would have been lost if such an approach had been accepted.

8.3 Agreeing the Challenges – Interim Report

As described in Chapter 7, the development of the Interim report was carried out using multiple rounds of Delphi Group feedback. The output of Expert Group sessions and desk research were used as the primary stimulus material in this phase. This was captured in the first sections of the Interim report. An early draft was circulated to the Expert Group. This allowed for an extensive peer-review by regional educationalists, industrialists and government representatives from National and Regional levels.

[58] A discussion of these mergers is provided in Chapter 2
[59] This was straightforward as the senior representative was on leave during this period

Feedback to the draft Interim report and subsequent changes and development can be summarised as falling within the three following categories;

- **Scope – Spatial** – The implications of the Knowledge Economy for different parts of the region were highlighted in some responses. Stakeholders acknowledged that Knowledge Economy developments and the growth of clusters are typically driven around municipalities, though much of the region cannot be characterised as such.

- **Scope – Sectoral** – While the Knowledge Economy has clear relevance to innovative enterprise in the Science, Engineering and Technology sectors, there exists in the region much enterprise in the Creative Industries sector. Some responses suggested discussion of this could be reinforced.

- **Linkages** – Another dimension concerned linkages between the Knowledge Economy agenda and other ongoing efforts looking at skills and business support. This issue related primarily to the narrative, rather than the challenges identified, and were incorporated in further versions of the report.

Development of each of these aspects is discussed in more detail in the following sections that present the individual challenges identified and researched.

Following incorporation of these changes, the report was ratified by the Expert Group as a proper and valid appraisal of the challenges faced by the region in the development of its Knowledge Economy. This provided the baseline for development of recommendations and actions to create a regional Knowledge Economy strategy.

8.4 Challenges Identified

The challenges identified fell into three main themes: Human Capital, Innovation and Infrastructure, with three cross-cutting themes of Market Needs, Collaboration and Communication (K Group 2006).

Many of the challenges identified were generic and are faced by any region. However, during the process it became clear that many had a particular regional perspective[60]. While Technium featured specifically in many of the challenges, the interdependencies of the Knowledge Economy mean that many other challenges affect Technium and vice-versa.

The following sections describe those challenges that relate to Technium, with discussion of how they relate to broader Knowledge Economy issues in a regional context. A full list of the challenges identified, together with their agreed descriptions in included in Appendix 17. While the Interim Report described the challenges according to the above themes, for the purpose of this discussion the following groupings have been adopted;

- Skills
- Support and Infrastructure
- Culture and Engagement

[60] As well as consideration being given to regional perspective of challenges, potential solutions also have a regional perspective, particularly in consideration of the scope of application of EU Convergence Funds

8.4.1 Skills

Challenges Identified

- Develop a skills supply to fulfil the needs of a regional Knowledge Economy
- Addressing a lack of key business skills in the region
- Review relevance, effectiveness and efficiency of education and training provision
- Develop the link between theory learnt in education and its practical application

Discussion

While Technium is not a skills initiative, it is highly dependent upon skills supply. Chapter 7 presented the high proportion of graduates employed in Technium companies, many of whom have SET expertise. The availability of such skills varies across the region with concentrated pockets of low educational attainment. Education sector representatives described how delivering higher skills to certain members of the community is impossible until the basic skills challenge is addressed. Therefore the Knowledge Economy skills agenda would have to dovetail with the broader skills agenda (WAG 2005c).

However, Technium does not rely solely upon home-grown higher level skills supply. In addition to the 'home' student population, the HE institutions in the region attract a large number of students, who not only develop skills at the institutions but also bring existing skills, along with other attribute such personal networks (that are often international in scope). Surveys have shown that at least 70% of these students would like to stay in the area if appropriate employment opportunities existed (WAG 2004). Indeed, as shown in the previous Chapter, Technium is delivering such opportunities. Contrary to the Cooke and Clifton (2005) charge that Technium is speculative, working to the old WDA thinking of – 'build it and they will come', this evidence would suggest the skills situation is more a case of – 'build it and they won't leave'.

As presented in Chapter 2, the 'Innovation Bridge' model (Clement 2004) describes the multiplicity of business skills required to successfully exploit ideas. Despite the encouraging improvements in entrepreneurship (GEM 2004), the Group identified the specific challenge of developing growing knowledge-based businesses. This observation ties in with that of the

Technium company survey, where the firms themselves recognised need for support in growing their businesses[61].

The business skills issue also interlinks with the question of relevance and effectiveness of education and training. Many of the private sector representatives highlighted the fact that the business schools in the region focus on delivering courses which provide skills of limited relevance in the region. The 'MBA'[62] was cited as an example, where the course content is more relevant to large corporations, of which very few are headquartered in South West Wales. In focusing on this type of course they do not develop the skill-set required for establishment and growth of small businesses[63], and in particular those which are knowledge-based. As effective management is a critical factor in success of knowledge enterprise (Kakati 2003), this challenge was regarded as particularly important by the private sector[64].

The problem of SET skills supply was also highlighted by various members of the Group. This is indeed a national problem, with a long-term downward trend in the uptake of science and engineering subjects at A-level and University (UK Gov 1999). However, the region has felt these pressures, with for example the closure of undergraduate chemistry at the University of Wales Swansea. However, representatives of the sectoral and professional bodies provided examples of how regional efforts can. Examples included the Engineering Education Scheme in Wales (EESW), supported by the Royal Academy of Engineering and the Faraday Lectures delivered by the Institution of Engineering and Technology (IET). Both programmes aim to inspire young people to undertake study in science and engineering leading to related careers.

[61] See also section 7.6.9
[62] MBA courses are provided at both the University of Wales Swansea and at Swansea Institute of Higher Education.
[63] This refers to the Higher Education business schools, specifically at the University of Wales Swansea and at Swansea Institute of Higher Education.
[64] See also Challenge Prioritisation, section 8.4

8.4.2 Support and Infrastructure

Challenges Identified

- Facilitating the evolution and strengthening of current business support to address the new challenges of the Knowledge Economy
- Support the Technium initiative and the wider incubation chain, to in particular develop earlier stage opportunities
- Development of a client-focused support infrastructure to face the new business development challenges of the Knowledge Economy
- Integration of the soft and physical business support infrastructure

Discussion

Several challenges identified by private and education sector representatives related to the way in which business support is delivered. The private sector described how a fragmented approach to business support often left companies being signposted back and forth between an array of initiatives and providers, with no accountability or responsibility for actual delivery. This challenge was compounded by the sheer number of programmes. A simple study, prepared by the School of Law Knowledge Economy Group at Swansea University underlined this by presenting how there were over 288 separate initiatives aiming to assist businesses in the region (K Group 2006a)[65]. The public sector recognised this as a challenge and stated that efforts were being made (WAG 2007b).

In light of the above, many representatives felt an 'evolution' of the nature and delivery of business support was required. This was challenged by members of the public sector support organisations who felt such an evolution was already underway. Technium was cited as an example of this; shifting focus from 'branch plant' inward investment and basic entrepreneurship to providing specialist assistance and focus on growth knowledge-based sectors (Technium 2005).

The relationship between the 'property development' and 'business support' agendas was discussed by the Group. This reflected the Cooke and Clifton (2005) argument that the (then)

[65] In fact, there may well be many more, as due to time constraints only 288 could be identified and examined

WDA operated more as a property developer than a business support agency. The Group as whole though felt that Technium presents an example of successful integration of the two missions. The collocation of support initiatives such as the Innovation Technology Counsellors and Know-How Wales at the Technium Centres correlates with a higher uptake of assistance, as shown in Chapter 7.

Due to its footprint across the region and various sectors, Technium featured in much of the discussion relating to development of growing knowledge-based businesses. However, representatives from all sectors highlighted challenges at either end of the Technium process; where the businesses originate from; and where they go upon graduation. The previous chapter has shown that Technium companies originate from a variety of sources, though as the network grows it will need greater input of new enterprise. Furthermore, the development of the 'Associate Membership' programme by Technium provides support to earlier stage opportunities. This programme will target enterprise which does not need tenancy at a Centre, but provides the support and other facilities available to tenants, together with hot-desk facilities.

At the other end of the process, the linkages developed by the companies, and the need for proximity to specific knowledge should act to help anchor and 'embed' them in the region following graduation (Asheim and Isaken 2002). This is supported by the Innovation System theory, where access to networks that underpin the company are core to the business' success (Porter and Stern 1999, Abbey et al. 2007).

Another dimension to this issue is the relationship of Technium with other 'incubators'. Examples of this is the 'Ideapolis' Business Incubation Centre at Neath Port Talbot College and the ECM2 Centre at Port Talbot, located next to Port Talbot steelworks. The former is aimed at early stage enterprise, though not necessarily knowledge-based, while ECM2 focuses on manufacturing, providing facilities for prototyping and development. Though both centres have different missions, the Expert Group felt there was clear opportunity to develop linkages and create a more integrated approach to business incubation and development in the region.

8.4.3 Culture and Engagement

Challenges Identified

- Developing a culture of innovation and aspirations for entrepreneurship through partnerships including schools and FE colleges
- Provide opportunities for Knowledge Economy skills to be utilised and developed
- Confronting a risk averse culture with a lack of risk management skills that is stifling innovation
- Raise the profile of the region and its activities beyond its borders

Discussion

Several of the regional difficulties identified by the Expert Group related to cultural issues and challenges of engagement of the wider community, particularly within stakeholders such as FE colleges. While such issues may not seem relevant to Technium, education sector representatives in particular were keen to highlight the role they felt Technium could play in addressing them.

Considering Technium as a component in a Regional Innovation System (Abbey et al. 2007) means it has inherent independencies, particularly in regard of key system factors such as 'the size and quality of the local workforce' and 'the degree to which national policy encourages innovation and commercialisation (Porter and Stern 1999). Therefore, by supporting these broader issues then Technium is, in effect, supporting itself.

In this regard, the Expert Group highlighted how Technium could be used as a regional beacon for the Knowledge Economy, both within and outside the region. Education representatives described how within the region the successes of Technium companies could inspire pupils and students by demonstrating potential career paths. Public sector representatives involved in Technium acknowledged it as an interesting idea, though were unsure about the practicalities. However, the Expert Group was reminded that this phase of the process was aiming to identify problems, not solutions.

Meanwhile, the opportunity to use Technium successes to develop the regional Knowledge Economy profile was identified by all stakeholders. Many of the private sector representatives described how one of the results of this would be to further develop networks, thereby further strengthening the Regional Innovation System (Cooke 1998, Abbey et al. 2007). A more formal example of this in practice is the partnership established with Fudan Science Park (FSP) in Shanghai. One of the aims of this partnership is to assist Technium and FSP companies aiming to develop opportunities in China and Wales[66].

[66] As part of this partnership the author of this study has developed a manual for Chinese companies: Establishing your European Base in Wales (Davies 2005). This manual is now being used by DEIN, in territories around the world.

8.5 Challenge Prioritisation

The purpose of the prioritisation exercise was not to determine a rank order of all the challenges, but rather to investigate which challenges each of the stakeholder groups; public, private and education saw as most important.

Responses were received from the entire Expert Group. They were examined and averages taken of the priority given to each. The top two were identified and presented to the Expert Group at the next meeting. No individual response was identifiable from the presentation. Described below are the top priorities identified by each of the stakeholder groups.

Human Capital Priorities

The prioritisation exercise produced immediate consensus regarding the top challenge regarding Human Capital (Table: 8.1). The need for focus on matching skills to market need was agreed by both 'supply' and 'demand' sides of the Expert Panel.

Private Sector Priorities	Public Sector Priorities	Education Sector Priorities
Provide skills matched to industry demand	Provide skills matched to industry demand	Provide skills matched to industry demand
Facilitate co-operation across institutions	Provision of Knowledge Economy Opportunities	Facilitate co-operation across institutions

Table: 8.1 Human Capital Challenge Priorities

The second priority for private and education sectors differed from that of the public sector. The public sector felt that provision of opportunities was the next most important challenge while other public stakeholders felt co-operation between institutions was a more pressing concern. This reflects the responses of the Stakeholder interviews where the private sector outlined their belief that creating the appropriate environment and deal flow would result in creation of opportunities.

Innovation Priorities

The most pressing innovation challenges identified differed markedly across groups (Table: 8.2). Whereas the public sector highlighted the challenge of attracting venture capital the private sector respondents put this near, or at the bottom, of their ordering.

Private Sector Priorities	Public Sector Priorities	Education Sector Priorities
Lack of business skills	Difficulties in attracting venture capital	Address challenge of risk averse culture
Develop suitable support for Knowledge Economy Challenges	Address challenge of risk averse culture	Develop suitable support for Knowledge Economy challenges

Table: 8.2 Innovation Challenge Priorities

The need for development of support to address Knowledge Economy challenges was highlighted by both private and education sectors and the problem of a risk-averse culture figured more highly for public and education sectors than their private sector counterparts. In the stakeholder interviews it was found that this risk aversion was often institutional and related to concerns about exposure of the reputation or finances of the organisation.

Infrastructure Priorities

The need for integration and client focussing of support was highlighted by private and education sector stakeholders (Table: 8.3). This reflected the views of many private sector stakeholders that current support provision provided too much signposting and too many providers with little focus on addressing specific and individual needs of businesses.

Private Sector Priorities	Public Sector Priorities	Education Sector Priorities
Development of a client-focused support infrastructure	Need for effective partnerships and collaboration	Development of a client-focused support infrastructure
Support wider development of Technium concept	Support wider development of Technium concept	Support wider development of Technium concept

Table: 8.3 Infrastructure Challenge Priorities

There was unanimity amongst the group that Technium provided a focus of the Knowledge Economy in the region and that one of the key priorities was to support the wider development of the Technium concept.

9. Conclusions

This study has set out to evaluate the role and impact of Technium in the development of the Knowledge Economy in South West Wales. As described in the first Chapters, it was shown how Technium has been developed to help address the economic challenges faced by Wales. Technium is a prime example of efforts being made in Wales to develop an entrepreneurial and innovative economy, in a region that has long been dependent upon traditional sectors, many of which have been in, and continue to, decline, while others face increased pressure from overseas competition.

It has been shown in this study that Technium has made a significant impact on the region and is playing a central role in the development of the regional Knowledge Economy. This study has taken a three-pronged approach which has demonstrated the significant economic impact which Technium has made to the region and the role it has played in supporting the development of vibrant growing knowledge-based enterprises, intensely engaged in innovation. Furthermore, it has been demonstrated how Technium helps the region develop certain 'characteristics', thereby playing a central role in a Sub-Regional Innovation System.

The following sections provide conclusions drawn from each aspect of the study, together with discussion regarding how the findings relate to the future of the initiative.

9.1 Returns on Investment

Technium is a major investment into the development of the Knowledge Economy in South West Wales representing £56.6m (in present value). Limited discussion of returns on this investment has been provided by observers including Bristow et al. (2007) and CSES (2006), both of whom focused on costs in relation to the jobs created to date[67].

In this study a wider range of impacts has been captured. In order to conduct this assessment a framework was developed which analysed Technium in 'optimistic', 'conservative' and 'base' scenarios. In each case it was found that Technium has returned net significant benefits.

Employment within the Centres currently represents some 329 jobs. However, herein lies one of the limitations of the 'cost per job' approach taken in studies such as those cited above. Technium is a dynamic initiative where the job creation is intended to be ongoing. By 2008, when

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[67] Discussion of these studies in Chapter 5 highlighted certain limitations in the approaches used.

all Centres in the Technium South West network are operational, it is envisaged that some 622 employees will be based therein. Furthermore, as companies graduate from Technium into the wider community, this will allow new enterprise and employment to be created; all stemming from the initial investment.

However„ it was also found that the economic impact of the initiative started before the Centres became operational. The construction phase was found to have generated employment within the community and created (directly and indirectly) an employment impact of almost £20m. This construction has returned to the region a set of valuable economic development assets in the form of the buildings themselves. Furthermore, these assets provide revenues which can be treated either as off-setting initial investment (as is the case in this study), or as income that can be invested in further development.

Putting values to, and combining, these impacts has allowed a more informed appreciation of the returns on investment provided by Technium. By assessing the value of benefits neglected by other assessments, it has been shown that Technium has, and continues to provide significant economic benefit to the region.

9.2 Developing Knowledge Enterprise

The survey amongst Technium companies, which was supported by a parallel survey amongst an appropriate Comparison Group, has demonstrated that Technium companies, generally, are growing faster, are more innovative, and are more intensely engaged in networking and collaboration, than companies not supported by the initiative.

The strong growth of Technium companies relates not only to their turnover but also the employment they create. It can also be concluded that the type of employment provided by Technium is of the type needed in the Knowledge Economy, as resident companies employ a higher number of graduates and have a greater proportion of employees engaged in innovation, even when compared to other 'knowledge-based' companies in the region.

It has been shown that Technium is supporting the development of a range of enterprise types, ranging from academic spin-outs to inward investors, all of whom exhibit a high propensity to collaborate and innovate. The higher level of engagement with academia amongst Technium, than observed both in companies outside and seen typically within science parks (UKSPA 2003), demonstrates that Technium is providing an effective conduit to academic knowledge and expertise.

The overall greater level of networking, collaboration and innovation by Technium companies compared to other companies in the wider community suggests that the initiative is succeeding in its support of the innovation process.

9.3 Technium in a Sub-Regional Innovation System

The nature and activities of companies in Technium demonstrates characteristic of a Sub-Regional Innovation System as proposed by Abbey et al. (2007). These characteristics have been found by demonstrating the intensity and scope of networking by Technium companies, identifying links with academia and recognising other phenomena such as the attraction of large corporations looking to supplement their internal R&D capabilities.

The role of Technium within this system has been further understood through the work associated with the development of a regional Knowledge Economy Strategy (Chapter 8). From this it is clear that Technium is recognised as an important component of this system and is seen as playing a potentially important role in the development of other core components.

9.4 Future Challenges

The Wales Spatial Plan work has shown how Technium will need to evolve in the face of future challenges and developments. As the network matures it will need to remain true to it ethos, while also supporting other activity within its Innovation System. Examples of this include its relationships with existing and future initiatives such as other incubators and science parks.

Meanwhile at a more basic level, the established Centres, Technium Swansea and Technium Digital have attracted and developed vibrant communities of resident companies. The challenge in the future for Technium is to replicate such success throughout the network, sustain a throughput of knowledge-based enterprise and support further growth phases of the companies it assists.

9.5 Summary of Conclusions

It has been shown that Technium has had a significant impact upon the region and is making progress in supporting the development of the Knowledge Economy in South West Wales. However, while this performance to date is encouraging, the true impact of Technium will remain incalculable for some time. This study provides a useful start in developing this understanding, though as Michael Porter stated in his address regarding the future competitiveness of Wales – "*Building strong regional economies takes decades*" (Porter 2002)

9.6 Further Work

The aim of this study has been to assess the impact of Technium and the role it plays in the development of the regional Knowledge Economy. However, as recognised throughout this study, the meaningful benefits of the initiative would be those seen in the future (EU 2002, Bristow et al. 2007, Science Alliance 2007). Therefore, in order to fully understand and assess the impact of Technium, evaluation needs to be ongoing and long-term.

In regard to the future challenges discussed earlier, the ongoing development of Technium is of interest. The initiative has been created as a partnership and how it maintains its ethos while maximising, and possibly expanding, its role and impact is of particular relevance to the future of the Knowledge Economy in South West Wales.

Another interesting perspective emerging from this study is collaboration within Technium companies, and between Technium companies and other organisations. This suggests elements of Open Innovation (Chesbrough 2003) behaviour are being exhibited. Open Innovation is a phenomenon that has been observed in many large corporations and may be worthy of further investigation as to whether small firms are exploiting the same route to commercialisation. In this regard, Technium may offer a useful case study for such investigation.

Appendices

Appendix 1 Glossary of Acronyms

BERD – Business Expenditure on Research and Development

DEIN – Department for Enterprise, Innovation and Networks

DELLS – Department for Education, Lifelong Learning and Skills

DfES – Department for Education and Skills

DTI – Department of Trade and Industry

ELWa – Education and Learning Wales (subsequently merged in DELLS)

FDI – Foreign Direct Investment

KEF – Knowledge Exploitation Fund

NAW – National assembly for Wales

NBIA – National Business Incubation Association

NPV – Net Present Value

NTBF – New Technology Based Firm

OECD – Organisation for Economic Cooperation and Development

SET – Science, Engineering and Technology

STPR – Social Time Preference Rate

TAG – Thematic Advisory Group

UKBI – United Kingdom Business Incubation

UKSPA – United Kingdom Science Park Association

WAG – Welsh Assembly Government

WDA – Welsh Development Agency (subsequently merged into DEIN)

WEFO – Welsh European Funding Office

WTI – Wales Trade International (subsequently merged into DEIN)

Appendix 2 Convergence Funding Frameworks

Thematic Frameworks

Research, technology and innovation *(ERDF Priority 1: Theme 1)*

Building business capacity to become more innovative and to develop new and improved products, processes and services. Developing research, technology and innovation capacity and the ability to commercialise and exploit research, including environmental goods and services (part of ERDF priority 2, theme 5).

Co-ordinating Organisation: DEIN, supported by DELLS

Partnership Arrangements: To include Regional Innovation Partnerships, Higher Education Wales, Business Partnership Council, Business Wales and appropriate sector fora.

Business Finance *(ERDF Priority 1: Theme 2 (Business finance))*

Assisting the growth and expansion of businesses by improving access to business finance.

Co-ordinating Organisation: DEIN

Partnership Arrangements: To include Business Partnership Council, Business Wales, appropriate sector fora, local government and voluntary sector.

Business Solutions *(ERDF Priority: Theme 3 (Entrepreneurship))*

Building a stronger environment for enterprise by supporting new and existing business ventures, particularly enterprises with the capacity to grow and by supporting and accelerating exports.

Co-ordinating Organisation: DEIN

Partnership Arrangements: To include Business Partnership Council, Business Wales, appropriate sector fora, local government and voluntary sector.

E Solutions *(ERDF Priority 1: Theme 4 (Information Society) and ERDF Priority 2: Theme 2 (ICT Infrastructure))*

Increasing the effective demand for, utilisation of, and embedded adoption of Information and Communication Technologies. Stimulating the development of an appropriate ICT infrastructure, where there is a clear market failure, for the benefit of both businesses and citizens.

Co-ordinating Organisation: DEIN

Partnership Arrangements: To include Business Partnership Council, E skills Council, Higher Education Wales and appropriate sector fora.

Sustainable Transport *(ERDF Priority 2: Theme 1)*

Increasing accessibility for all by developing and implementing sustainable transport solutions and infrastructure, by supporting the regional transport plans that are being worked up linked to the Spatial Planning process.

Co-ordinating Organisation: DEIN

Partnership Arrangements: To include Wales Transport Forum, Regional Transport Partnerships.

Climate Change *(ERDF Priority 2: Theme 3 and Priority 2: Theme 4)*

Overarching strategic framework co-ordinated jointly by DEIN and Environment Planning and Countryside (EPC) with two strands: Energy; and Climate Change Adaptation.

Co-ordinating Organisation: jointly co-ordinated by DEIN and Environment Planning and Countryside (EPC)

Partnership Arrangements: To include Climate Change group and Wales Energy Forum.

Energy *– supporting the development of clean and renewable energy and encouraging greater energy conservation and efficiency by businesses, public bodies, social enterprises, local communities and householders.*
Co-ordination: DEIN lead, supported by EPC.

Climate Change Adaptation *– adaptation to and mitigation of the effects of Climate Change, including improving flood and coastal defence infrastructure,*

tackling the legacy of contaminated land, minimising run-off and other diffuse pollution and reducing green house gas emissions.
Co-ordination: EPC lead, supported by DEIN.

Environmental Risks – Waste Management *(ERDF Priority 2: Theme 4)*

Improving materials resource efficiency through the reduction, reuse and recovery of materials and water, including investment in R&D and innovation to develop innovative solutions in waste recovery technologies. Minimizing the production and landfill of waste by businesses.

Co-ordinating Organisation: EPC

Partnership Arrangements: To include Wales Waste Forum

Community Economic Development *(ERDF Priority 3: Theme 2)*

Tackling the underlying issues that prevent sustainable economic and social development within communities, including increasing the sustainable the participation and growth of community and social enterprises within the mainstream economy

Co-ordinating Organisation: Social Justice and Regeneration Department (SJR)

Partnership Arrangements: To include Voluntary Sector Partnership Council, Social Enterprise Joint Working Group

Spatial Frameworks

Environment for growth *(ERDF Priority 2: Theme 5)*

Realising the economic potential of the environment through enhancing and protecting the natural, built and heritage environment in ways which promote sustainable economic growth.

Co-ordinating Organisation: Spatial Plan Area Groups, supported by DEIN and EPC.

Partnership Arrangements: There will be separate frameworks for each of the Spatial Plan areas.

Building Sustainable Communities *(ERDF Priority 3: Theme 1)*

Supporting the physical regeneration of communities, including the development of high quality business sites and premises, the redevelopment of brownfield sites and landscape improvements

Co-ordinating Organisation: Spatial Plan Area Groups supported by DEIN.

Partnership Arrangements: There will be separate frameworks for each of the Spatial Plan areas.

Appendix 3 Exploratory Study of Patenting in US/UK Universities

Exploratory Study of Patenting in US/UK Universities and Effect of time taken to grant

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Abstract

This paper describes a short study investigating the time taken to grant from application for recent patents granted to UK and US universities. The granting of patent protection provides an indication of the novelty of an invention, of freedom to operate and protection of monopoly and market potential. The study shows that from a survey of patents recently granted to UK and US universities, that US institutions generally receive grants earlier on, providing earlier clarity of invention status and assisting in licensing to and raising of finance by the licensee.

1. Introduction

The role of university research to fuel innovation and academia's management of Intellectual Property has received much study over recent years by both academics(1)(2) and governments (3), particularly with regard to invention licensing(4)(5)(6). Studies have examined aspects such as effect of incentives, university location and the university technology transfer office (TTO) operations(7)(8).

Some studies have shown most university technologies to be so far from market they can be considered at point of licence as being of limited initial value(1)(9). A patent will however provide a measure of protection for the licensee with regard to the potential market and when developed may be of significant value, i.e. helping to clarify freedom to operate and monopoly over the technology. It is at the outset of taking an invention to innovation that raising finance can be most challenging, particularly for radical ventures such as those arising from university research(10). Raising finance in this period of technology development is a critical challenge for firms who need to develop assets and markets before competitors work around their IP(10).

This study aims to explore the timescale of the patenting process and how this may affect the licensing of a technology and whether US and UK University TTOs enjoy the same timescales in receiving grants of patent applications. As the granting of a patent is an important aspect of its value(11) the sooner it is granted the earlier this value is unlocked or validated thereby making it easier to license the technology. The study aims to identify whether there is a difference in timescales that affect when such clarity is provided.

Furthermore, in this analysis patent bibliometrics based upon the citations included in patents provide a window on the technology, its inventor and value building upon techniques used to appraise academic publication productivity[12]. Citation analysis has been used to investigate various phenomena and studies have focused on issues such as knowledge spillovers[13][14], international knowledge flows, the value of inventions[15], the impact of publicly-funded research[16] and competitive strategy[17][18].

The interplay between university research and innovation has been shown[19] and the use of patent citations to explore this has also been demonstrated[20]. Citation analysis of university patents has been found to be more reliant on scientific, rather than technological sources[21].

2.1 Stage 1 – Exploratory Study

This research project commenced with an exploratory study based around interviews with technology transfer managers at a range of institutions in both countries. The interviews were conducted with managers from institutions including in both countries those categorized as 'Ivy-league' (e.g. Oxbridge), 'red-brick' (e.g. Pre-1992 Research-led) and 'New' (e.g. Ex-Polytechnic). Aimed initially at investigating technology transfer practices and experiences in a broad sense, it became apparent that key to the behaviour of technology transfer offices was the manner and timescales in which it acquired protection of IP.

2.2 Exploratory Study Findings

The exploratory study indicated that US universities may benefit from certain advantages arising from the nature and performance of their national patent system. The discussions revealed that US institutions had two particular advantages over UK counterparts. The first relates to use of the provisional patenting system in the country that allows a less expensive filing to be made, providing a priority date at minimal cost and with less initial information about the invention than a full filing. The second advantage was that full patents appeared to be granted more quickly and generally before PCT decisions, when significant costs were incurred. Further to this, technology transfer managers in the US were far less likely to consider taking an invention past the PCT stage without a partner to share the costs, thereby concentrating on a faster commercialization process.

This gave the exploratory study the broad conclusion that US universities could employ a strategy of more widespread patenting with patents being granted earlier, making technologies more appealing to potential licensees. Having patent applications granted significantly more quickly through their national systems than their UK counterparts provides earlier clarity of protection status increasing invention value and reducing risk in embarking upon further development. This assists a University in a number of ways to licence/develop an invention, by providing a strong indication of freedom to operate and establishing security of monopoly for the invention, along with a demonstration of uniqueness. This creates a stronger position for the University in offering the technology to potential licensees as it creates a stronger case for raising finance for development, as the market potential for the invention is more clearly defined.

2.3 Stage 2 – Empirical Study

To follow up the findings from the interview stage, a statistical study was undertaken to examine whether empirical evidence could be collated to demonstrate the existence of such advantages. The empirical study focused on a significant number of recently granted University-held patents awarded through the national patenting system (100 in the UK and 500 in the US). Data gathered included the time to grant and information relating to numerous possible factors affecting this, such as type of invention, etc. These datasets were then correlated with other available data on University patenting to ensure it was properly representative, including information from the AUTM[4] and HEFCE[5] surveys, and drew extensively upon the kind support of IP Wales, for both comparison of datasets and development of the understanding of IP being used as a financial tool.

2.4 Empirical Study Findings

2.4.1 Time to Grant – Overall

Initial analysis of the data showed that US patents were typically granted more quickly as shown in Fig. 1 below. Crude averages give a time to grant of 35 and 40 months for US and UK patents respectively. However, a group of rather drawn-out US patents which are described later in more detail distort this significantly. Further, the far higher proportion of biotechnology inventions in the US (which generally took longer to grant) also act to increase this average.

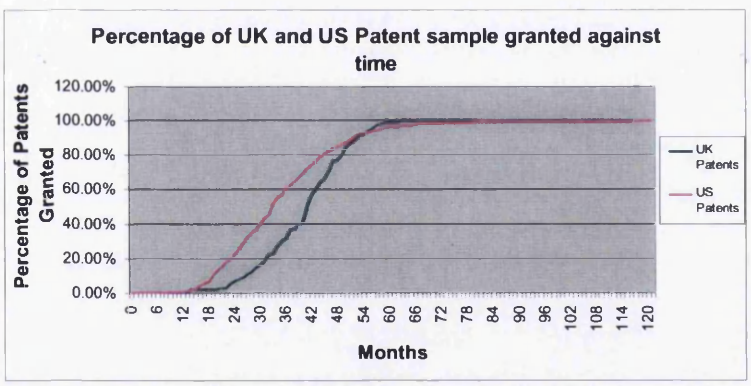

Fig. 1 UK and US Patent Grant Times

It can though be seen that almost half of US patents were granted before month 30, while only 15% of UK grants had been made by this point. This provides US universities with a stronger position to license many of their technologies before expensive PCT decisions are required. The crossover around month 55 shown in Fig.1 and relates to around 3.5% of the US patents that take over 60 months. This is partly an effect of the fact that the UK patent data used made it difficult to identify applications that took longer than five years. This data would generally be discarded as an anomaly as direct comparison is difficult and falls outside the period of interest.

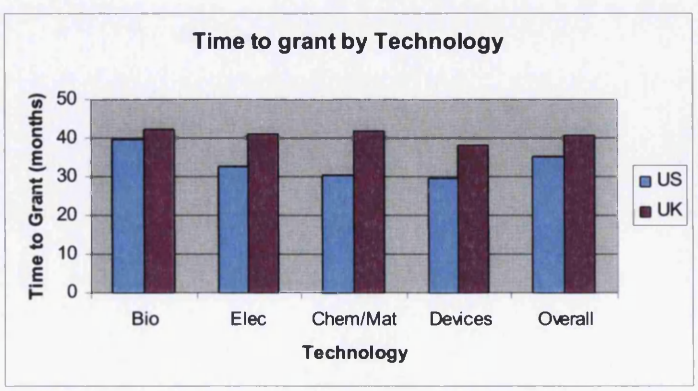

Fig. 2 Grant Time by Technology

2.4.2 Time to Grant – By Sector

Several interesting points can be observed when examining averages of time taken to grant for technologies in different fields. This is presented in Fig. 2 below. Patent grant times for UK inventions was relatively independent of invention type, with the slight exception of devices (e.g. 'widget' type inventions that do not fall within the other categories). The general trend of faster grant times for US inventions can be seen in the averages for all technologies, with only grant time for biotech inventions being comparable with the UK.

The average time to grant for biotechnology inventions is relatively close in both the UK and US systems. This data must be considered in the context of a massive increase in patenting in the US, and an explosion in the number of biotechnology inventions. This was at the time of a reported shortage of examiners in the US with appropriate expertise to handle this massive increase.

2.4.3 Industry and International Involvement

Also uncovered in the study was the participation of an industrial (joint filing with company) or international (foreign co-inventor or industrial co-assignee) partner in applying for patent protection.

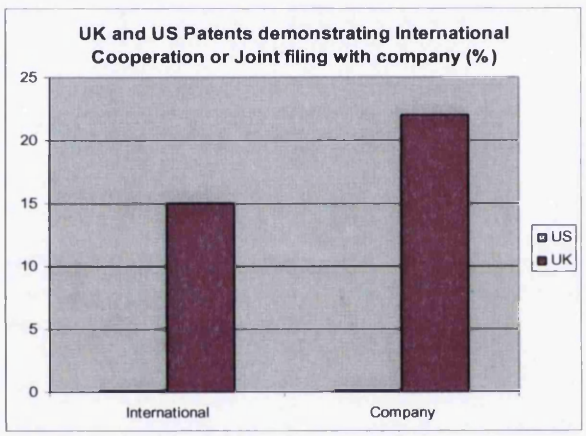

Fig. 3 International and Company Co-operation

The levels of co-operation identified in the US and UK are shown to the left in Fig. 3. This shows a far greater proportion of UK patents awarded in partnership with industry. This reflects the explorative study, indicating that UK universities were more eager to defray the higher initial patenting costs to an industrial partner but can also be interpreted as a positive indication of UK universities' ability and willingness to engage with industry.

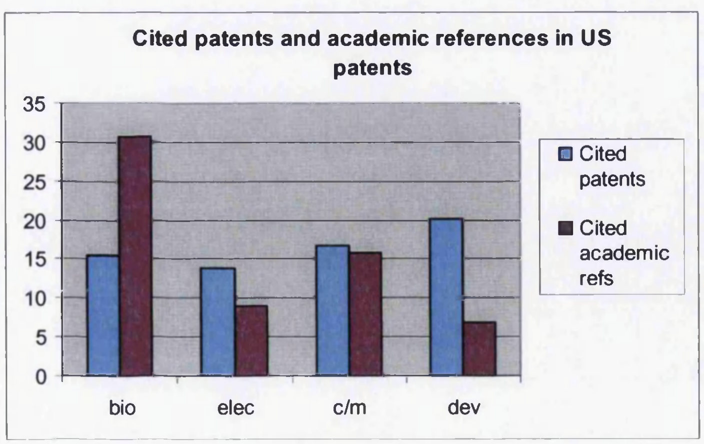

Fig. 4 Patent Citations and Academic References

The 'International' comparison may be a little unfair on the US, as interstate may represent a greater geographical distance than cross-channel co-operation. However, the language and logistical challenges faced by UK universities embarking upon such collaboration should be recognized. This therefore makes an impressive showing of UK universities collaborating on an international stage. Combined with the higher level of industrial co-operation during application this also presents a strong positive indication of patent value in the UK.

2.4.4 Role of Academic Knowledge

The study has aimed to identify differences in the type of invention that could affect the time taken to process applications. This included looking at citations of prior work that relates to the invention for each type of invention. Fig. 4 shows an average count of patent and academic references cited for each invention type. This shows that while 'devices' are more closely related to existing patented inventions, biotechnology inventions are closer to academic literature. For biotechnology inventions this means an examiner may often be confronted by a field and literature with which he is less familiar. This would demonstrate that biotechnology invention applications could be more difficult to process and may therefore take longer.

3. Conclusion

The findings from the research described above would indicate that US universities, and industry, enjoy an advantage over their UK counterparts by seeing protection of inventions being granted earlier. This allows them to develop and exploit technologies more quickly and effectively, by reducing risks allowing finance to be acquired more easily providing faster innovation, giving the further advantage of faster time to market. The research also demonstrated how the time to grant varies with type of invention, along with a correlation with the knowledge to which the invention relates.

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Appendix 4 GDP Deflators

Source: HM Treasury 2007

GDP DEFLATORS AT MARKET PRICES, AND MONEY GDP

Outturn data are the latest national accounts figures from ONS - Last updated 28 March 2007
Forecast data are consistent with the Budget Report 2007

GDP Deflator Table

Financial Year	GDP deflator at market prices 2005-06 =100	percentage change on previous year
1964-65	7.134	4.69
1965-66	7.484	4.91
1966-67	7.801	4.23
1967-68	8.025	2.87
1968-69	8.407	4.76
1969-70	8.861	5.41
1970-71	9.596	8.30
1971-72	10.459	8.99
1972-73	11.343	8.46
1973-74	12.136	6.99
1974-75	14.516	19.61
1975-76	18.214	25.47
1976-77	20.671	13.49
1977-78	23.493	13.65
1978-79	26.090	11.06
1979-80	30.486	16.85
1980-81	36.037	18.21
1981-82	39.478	9.55
1982-83	42.271	7.08
1983-84	44.235	4.65
1984-85	46.558	5.25
1985-86	49.103	5.47
1986-87	50.693	3.24
1987-88	53.538	5.61
1988-89	57.271	6.97
1989-90	61.366	7.15
1990-91	66.184	7.85
1991-92	70.229	6.11
1992-93	72.491	3.22
1993-94	74.381	2.61
1994-95	75.505	1.51
1995-96	77.802	3.04

Money GDP Table

Financial Year	Money GDP Cash £ million
1964-65	33,939
1965-66	36,372
1966-67	38,574
1967-68	40,880
1968-69	44,376
1969-70	47,601
1970-71	52,893
1971-72	59,123
1972-73	67,135
1973-74	74,743
1974-75	89,204
1975-76	111,207
1976-77	129,803
1977-78	151,017
1978-79	172,739
1979-80	207,696
1980-81	236,623
1981-82	259,637
1982-83	283,574
1983-84	308,550
1984-85	331,094
1985-86	363,161
1986-87	388,639
1987-88	431,873
1988-89	480,574
1989-90	525,906
1990-91	564,627
1991-92	596,058
1992-93	616,689
1993-94	653,474
1994-95	690,449
1995-96	730,891

1996-97	80.421	3.37
1997-98	82.759	2.91
1998-99	84.863	2.54
1999-00	86.579	2.02
2000-01	87.796	1.41
2001-02	89.880	2.37
2002-03	92.661	3.09
2003-04	95.416	2.97
2004-05	98.047	2.76
2005-06	100.000	1.99
2006-07[1]	102.478	2.48
2007-08[1]	105.242	2.70
2008-09[1]	108.083	2.70
2009-10[1]	111.001	2.70
2010-11[1]	113.998	2.70

1996-97	774,745
1997-98	824,212
1998-99	871,243
1999-00	921,881
2000-01	965,494
2001-02	1,006,906
2002-03	1,064,183
2003-04	1,128,191
2004-05	1,187,500
2005-06	1,241,106
2006-07[2]	1,306,000
2007-08[2]	1,378,000
2008-09[2]	1,450,000
2009-10[2]	1,525,000
2010-11[2]	1,604,000

Sources and footnotes:

GDP Deflator: For years 1964-65 to 2005-06: calculated from ONS data for seasonally adjusted current and constant price GDP (YBHA and ABMI)

For years 2006-07 to 2010-11: derived from HM Treasury forecasts for GDP deflator increases at the Budget Report 2007

Cash GDP: For years 1964-65 to 2005-06: ONS data for money GDP (not seasonally adjusted, BKTL)

For years 2006-07 to 2010-11: HM Treasury forecasts for money GDP at Budget Report 2007.

Footnotes:

(1) For years 2006-07 to 2010-11, GDP deflator forecasts derived from unrounded forecast increases in GDP deflator, consistent with Budget Report 2007

(2) For years 2006-07 to 2010-11, money GDP forecasts as shown in the Budget Report 2007 rounded to nearest £ billion. These are the lower end of HM Treasury's forecast range and are consistent with the deliberately cautious assumption of trend growth used as the basis for projecting the public finances.

(3) For further information and the 'User's Guide' to these series, please visit the following page on HM Treasury's public website at: http://www.hm-treasury.gov.uk/Economic_Data_and_Tools/GDP_Deflators/data_gdp_index.cfm

Appendix 5

GDP and Employment Multipliers by Sector
Source: Welsh Economy Research Unit (WERU) 2007

Sector	GDP Multiplier	Employment Multiplier
Agriculture, Forestry and Fishing	1.61	1.38
Extraction	1.45	1.78
Food, Drink and Tobacco	1.48	1.98
Textiles and Clothing	1.33	1.29
Wood, Paper, Pulp, Publishing and Printing	1.55	1.63
Oil and Chemicals	1.50	2.32
Rubber and Plastics	1.43	1.44
Other Non Metals	1.50	1.64
Manufacture of Basic Metals	1.86	2.31
Metals, Mechanical Engineering and Other Machinery	1.43	1.41
Electronic Engineering	1.52	1.61
Automotive Components and Transport Equipment	1.49	1.66
Other Manufacturing	1.60	1.50
Construction	1.70	1.43
Retail and Wholesale	1.47	1.33
Other Services	1.40	1.45

* Source: The Effectiveness of Regional Grant Aid: A Welsh Perspective, Munday, Pickernell and Roberts, Paper presented to the 39th European Congress of Regional Science Association, 1999

Appendix 6

Impact Assessment

Base Model

April 2007

1. Technium Network in South West Wales

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	285,000	1,924,000	0	4,856,893	3,686,596	11,749,993	9,926,976	4,426,525	0	0	**36,855,983**	
Revenue (All Non-Capital Costs)	0	415,500	461,500	860,736	1,296,920	3,318,555	2,672,474	2,050,103	1,265,850	1,305,000	**13,646,638**	
Total	285,000	2,339,500	461,500	5,717,629	4,983,516	15,068,548	12,599,450	6,476,628	1,265,850	1,305,000	50,502,621	
Costs (Cumulative)												
Capital	285,000	2,209,000	2,209,000	7,065,893	10,752,489	22,502,482	32,429,458	36,855,983	0	0	**36,855,983**	
Revenue	0	415,500	877,000	1,737,736	3,034,656	6,353,211	9,025,685	11,075,788	0	0	**13,646,638**	
Total	285,000	2,624,500	3,086,000	8,803,629	13,787,145	28,855,693	41,455,143	47,931,771	47,931,771	47,931,771	50,502,621	
Investment												
Obj 1	108,000	929,800	184,600	2,966,807	2,383,669	5,846,464	4,424,500	2,984,164	0	0	**19,828,004**	39
WAG	171,000	1,346,700	201,282	299,719	1,026,152	5,988,954	5,118,057	2,545,069	0	0	**16,696,933**	33
UWS	0	57,000	57,000	320,983	1,285,027	1,037,819	670,906	455,791	0	0	**3,884,526**	8
Other Public Funds	0	0	0	2,023,120	135,400	163,138	2,102,623	339,855	1,265,850	1,305,000	**7,334,986**	15
Other Private Funds	6,000	6,000	18,618	80,000	153,268	2,032,173	283,364	151,749	0	0	**2,731,172**	5
Total	285,000	2,339,500	461,500	5,690,629	4,983,516	15,068,548	12,599,450	6,476,628	1,265,850	1,305,000	50,475,621	100
Investment (Inflation and STPR adjusted)											47,744,449	Public Sector
Total	426,785	3,317,846	623,883	7,295,991	5,957,243	16,901,352	13,287,851	6,476,628	1,190,860	1,155,754	56,634,194	
Total	426,785	3,744,632	4,368,514	11,664,505	17,621,749	34,523,101	47,810,951	54,287,579	55,478,440	56,634,194	56,634,194	
GDP Deflator (factor) Inflation Deflators*	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948		
Discounting STPR (factor)	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934		

2. Employment and Wages Impact

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Direct Jobs - Companies										
Technium Company Jobs	0	0	0	79	117	166	199	299	450	600
Technium Support Jobs	0	4	8	10	12	18	22	22	22	22
Sub Total (Direct Employment)	0	4	8	89	129	184	221	321	472	622
In-Direct Jobs - Multiplier										
Multiplier (1.5)	0	2	4	45	65	92	111	161	236	311
Total Jobs *(Direct + Multiplier)*	0	6	12	134	194	276	332	482	708	933
Direct Jobs - Graduated Companies										
Jobs in Graduated Companies	0	0	0	0	0	0	0	20	50	110
Multiplier (1.5)	0	0	0	0	0	0	0	10	25	55
Total Jobs (In and beyond network)	0	6	12	134	194	278	332	512	783	1,098
Impact - Direct										
Average Compensation (£)	20,000	21,000	21,000	21,000	21,000	22,000	23,000	24,000	25,000	26,000
Average Individual Contribution (inc. 22% costs)	24,400	25,620	25,620	25,620	25,620	26,840	28,060	29,280	30,500	31,720
Direct Contribution to Region Employment	0	102,480	204,960	[illegible]	[illegible]	[illegible]	[illegible]	9,984,480	15,921,000	23,219,040
Cumulative of Impact Direct	0	102,480	307,440	2,587,620	5,892,600	10,831,160	[illegible]	[illegible]	[illegible]	[illegible]
Impact - Indirect										
Average Compensation (£)	18,652	19,386	20,062	21,070	21,934	23,093	23,645	24,423	25,320	26,307
Average Individual Contribution (inc. 22% costs)	22,755	23,651	24,475	25,705	26,759	28,173	28,847	29,796	30,890	32,095
Indirect Contribution to Region Employment	0	47,302	97,901	1,143,890	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cumulative of Impact (Direct and Indirect)	0	47,302	145,202	1,289,093	3,015,079	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total Impact (Inflation and STPR adjusted)										
Techium Contribution to Region Employment	0	212,419	409,425	4,369,291	6,013,965	8,446,464	9,901,824	15,064,708	22,562,604	30,966,812
Techium Contribution to Reg Emp (Cum)	0	212,419	621,843	4,991,134	11,005,100	19,451,563	29,353,387	44,418,095	66,980,700	97,947,511
GDP Deflator (factor) Inflation Deflators*	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948
Discounting STPR (factor)	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934

Assumptions
Multiplier (0.5)Indirect & Induced Jobs 0.166666667
Support is included in the Direct Jobs
Multiplier is income coming into the worker monthly
Graduated Jobs count in Economic Output of Technium
Average Salary = £21,000 and incrimental increase per annum

For Chart Prep Only

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008		
Direct Impact - Numbers												
Jobs	0	4	8	89	129	184	221	321	472	622		
Direct Impact - Value (Inflation and STRP adjusted)												
Cumulative of Impact Direct	0.00	0.15	0.42	3.39	7.04	12.18	17.96	27.02	40.39	58.59		
1000000												
Indirect Impact - Numbers												
Jobs	0	2	4	45	65	92	111	171	261	366		
Direct Impact - Value (Inflation and STRP adjusted) By Year												
Cumulative of Impact Direct	0.00	0.15	0.28	2.91	3.95	5.54	6.54	9.98	14.98	20.56		
1000000												
Indirect Impact												
£	0	0	0	1	2	3	3	5	8	10	Total	33
1000000												

Construction - Employment and Expenditure

Technium 1 (2000)

Factor 0.48

	2000	2001	Total
Total Spend:	2,200,000.00		2,200,000.00
Construction Period: (months)	12.00	3.00	15.00
Average Jobs/Period:	18.65	18.65	18.65
Average Local Jobs:	16.79	16.79	16.79
Average Wage:	27,700.00	27,700.00	27,700.00
Total Wage:	464,998.70	116,249.67	581,248.37
Professional Fees:	129,474.78	32,368.70	161,843.48

Digital Technium (2003)

	2002	2003	Total
Total Spend:	4,600,000.00		4,600,000.00
Construction Period: (months)	3.00	12.00	15.00
Average Jobs/Period:	39.00	39.00	39.00
Average Local Jobs:	35.10	35.10	35.10
Average Wage:	27,700.00	27,700.00	27,700.00
Total Wage:	243,060.00	1,215,300.00	1,458,360.00
Professional Fees:	56,400.00	282,000.00	338,400.00

Technium 2 (2003)

Factor 0.87

	2002	2003	Total
Total Spend:	4,000,000.00		4,000,000.00
Construction Period: (months)	3.00	12.00	15.00
Average Jobs/Period:	33.91	33.91	33.91
Average Local Jobs:	30.52	30.52	30.52
Average Wage:	27,700.00	27,700.00	27,700.00
Total Wage:	211,363.04	845,452.17	1,056,815.22
Professional Fees:	49,043.48	245,217.39	294,260.87

Technium ST (2005)

Factor 1.43

	2004	2005	Total
Total Spend:	6,600,000.00		6,600,000.00
Construction Period: (months)	6.00	9.00	15.00
Average Jobs/Period:	47.28	47.28	47.28
Average Local Jobs:	42.56	42.56	42.56
Average Wage:	31,537.00	31,537.00	31,537.00
Total Wage:	671,107.36	1,006,661.04	1,677,768.40
Professional Fees:	156,000.00	234,000.00	390,000.00

Technium PE (2006)

Factor 1.13

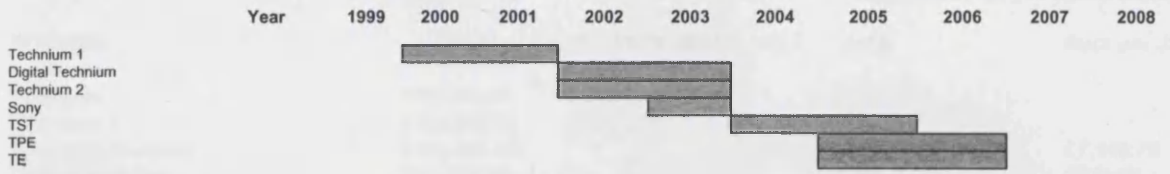
	2005	2006	Total
Total Spend:	5,200,000.00		5,200,000.00
Construction Period: (months)	12.00	12.00	24.00
Average Jobs/Period:	27.55	27.55	27.55
Average Local Jobs:	24.80	24.80	24.80
Average Wage:	31,537.00	31,537.00	31,537.00
Total Wage:	782,083.32	782,083.32	1,564,166.64
Professional Fees:	191,269.57	191,269.57	382,539.13

Technium Energy (2005)

Factor 2.28

	2005	2006	Total
Total Spend:	10,500,000.00		10,500,000.00
Construction Period: (months)	12.00	12.00	24.00
Average Jobs/Period:	55.64	55.64	55.64
Average Local Jobs:	50.07	50.07	50.07
Average Wage:	31,537.00	31,537.00	31,537.00
Total Wage:	1,579,206.71	1,579,206.71	3,158,413.41
Professional Fees:	386,217.39	386,217.39	772,434.78

4. Construction Phase and Fixed Assets*



Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
No. of Jobs Supported										
% of "Local" Jobs	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Total Local Jobs										
Average Compensation	22,705	22,705	22,705	22,705	22,705	25,850	25,850	25,850	25,850	25,850
Average Individual Contribution (inc. 22% costs)	27,700	27,700	27,700	27,700	27,700	31,537	31,537	31,537	31,537	31,537
Site Operations Contribution (Wages)	0	464,999	116,250	454,423	2,060,752	671,107	3,367,951	2,361,290	0	0
Professional Fees Contribution	0	129,475	32,369	105,443	527,217	156,000	811,487	577,487	0	0
Total Direct Contribution*	0	594,473	148,618	559,867	2,587,970	827,107	4,179,438	2,938,777	0	0
Total Multiplier Contribution (1.5)	0	297,237	74,309	279,933	1,293,985	413,554	2,089,719	1,469,388	0	0
Total Construction Contribution	0	891,710	222,928	839,800	3,881,954	1,240,661	6,269,157	4,408,165	0	0

* Totalled from calculations for individual projects on previous page

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Construction Contribution (cum)	0	891,710	1,114,638	1,954,438	5,836,392	7,077,053	13,346,210	17,754,375	17,754,375	17,754,375

Construction Impact (Inflation and STPR adjusted)

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Construction Contribution	0	1,264,611	301,367	1,071,628	4,640,448	1,391,564	6,611,687	4,408,165	0	0
Total Construction Contribution (cum)	0	1,264,611	1,565,978	2,637,606	7,278,054	8,669,618	15,281,305	19,689,470	19,689,470	19,689,470
Inflation Deflators* — GDP Deflator (factor)	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948
Discounting — STPR (factor)	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934

Fixed Assets

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Return	0	2,200,000	0	8,600,000	0	6,600,000	15,700,000	0	0	0
Total Return (Cum)	0	2,200,000	2,200,000	10,800,000	10,800,000	17,400,000	33,100,000	33,100,000	33,100,000	33,100,000

Fixed Assets (Inflation and STPR adjusted)

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Return	0	3,120,009	0	10,974,045	0	7,402,765	16,557,806	0	0	0
Total Return (Cum)	0	3,120,009	3,120,009	14,094,055	14,094,055	21,496,820	38,054,626	38,054,626	38,054,626	38,054,626

Construction Phase Chart Prep

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Construction Contribution	0.0	1.3	1.6	2.6	7.3	8.7	15.3	19.7	19.7	19.7

1000000

Non-cumulative employment impacts

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Impact in Year	0.0	1.3	0.3	1.1	4.6	1.4	6.6	4.4	0.0	0.0

1000000

Rental Income - Model and Projections

BUILDING	RENT	PROPERTY (BOOK VALI	Jobs	Rent per Job	
Technium 1	£97,027.00	1,550,000			
Technium 2	£158,005.00	3,100,000			
Technium Swansea	£255,032.00		222	£1,148.79	
Digital Technium	£49,502.00		51	£970.63	
Sustainable Technologies (Baglan)	£29,773.00		31	£960.42	
Performance Engineering (Auto)	£0.00		4		
ECM2	N/A	N/A			
Aberystwyth Technium	£40,050.00		28	£1,430.36	
Optic Technium	£128,110.00		87	£1,472.53	
CAST Technium	£150,000.00		112	£1,339.29	
SONY Digital	£14,100.00		9	£1,566.67	
Pembroke	£0.00		4		
	Total		Total	Overall	
	£921,599		548	£1,681.75	1682

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Rent per Job	£1,428.51	£1,457.40	£1,477.91	£1,512.99	£1,559.79	£1,606.17	£1,650.44	£1,681.75	£1,726.87	£1,773.59
Total Rent	**£0.00**	**£5,829.62**	**£11,823.24**	**£134,655.79**	**£201,212.84**	**£295,535.68**	**£364,746.32**	**£539,841.75**	**£815,083.28**	**£1,103,173.21**
Total Rent NPV (STPR and Inf. Adj)	**£0.00**	**£8,267.48**	**£15,983.35**	**£171,827.76**	**£240,527.75**	**£331,482.01**	**£384,675.09**	**£539,841.75**	**£766,797.28**	**£977,009.30**
Total Rent NPV (STPR and Inf. Adj)	**£0.00**	**£8,267.48**	**£24,250.84**	**£196,078.60**	**£436,606.35**	**£768,088.36**	**£1,152,763.44**	**£1,692,605.19**	**£2,459,402.47**	**£3,436,411.77**
Occupancy	0	4	8	89	129	184	221	321	472	622
Occupancy Adjustment										
Inflation Adjustment	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948
STPR Adjustment	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934

6. Investment Comparison

	Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	Present Value Total 2008
Investment†											
Total		426,785	3,744,632	4,368,514	11,664,505	17,621,749	34,523,101	47,810,951	54,287,579	55,478,440	56,634,194
Employment Contribution†											
Total Return		0	212,419	621,843	4,991,134	11,005,100	19,451,563	29,353,387	44,418,095	66,980,700	97,947,511
Fixed Assets*†											
Total Return		0	2,340,007	2,340,007	10,570,541	10,570,541	16,122,615	28,540,970	28,540,970	28,540,970	28,540,970
Construction Phase†											
Total Return		0	1,264,611	1,565,978	2,637,606	7,278,054	8,669,618	15,281,305	19,689,470	19,689,470	19,689,470
Rental Income											
Total Return		0	8,267	24,251	196,079	436,606	768,088	1,152,763	1,692,605	2,459,402	3,436,412
Total Technium Return											
Total Return		0	3,825,304	4,552,079	18,395,360	29,290,301	45,011,884	74,328,425	94,341,141	117,670,542	149,614,363

* Fixed Assets line assumes building value of 50% of construction cost
† Adjusted in Linked Table for Inflation and STPR (as below)

NPV	92,980,169
B/C	2.642

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Inflation Deflators	GDP Deflator (factor)	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948
Discounting	STPR (factor)	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934

Fixed Assets Chart Prep

Total Return		0.0	2.3	2.3	10.6	10.6	16.1	28.5	28.5	28.5	28.5
1000000											

Technium 1

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	285,000	1,924,000	0	0	0	0	0	0	0	0	2,209,000	
Revenue	0	415,500	461,500	0	0	0	0	0	0	0	877,000	
Total	285,000	2,339,500	461,500	0	0	0	0	0	0	0	3,086,000	
Investment												
Obj 1	108,000	929,800	184,600	0	0	0	0	0	0	0	1,222,400	40
WAG	171,000	1,346,700	201,282	0	0	0	0	0	0	0	1,718,982	56
UWS	0	57,000	57,000	0	0	0	0	0	0	0	114,000	4
Other Public Funds	0	0	0	0	0	0	0	0	0	0	0	0
Other Private Funds	6,000	6,000	18,618	0	0	0	0	0	0	0	30,618	1
Total	285,000	2,339,500	461,500	0	0	0	0	0	0	0	3,086,000	100
Jobs in Technium Co's	0	0	0	59	97	146	159	216	216	216		
Jobs in Technium Support	4	4	4	4	4	4	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	0	0		

Adjustment figure for previous employment
30

Technium Digital

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	729,954	3,686,596	3,282,134	0	0	0	0	**7,698,684**	
Revenue	0	0	0	40,416	597,980	825,290	541,330	0	0	0	**2,005,016**	
Total	**0**	**0**	**0**	**770,370**	**4,284,576**	**4,107,424**	**541,330**	**0**	**0**	**0**	**9,703,700**	
Investment												
Obj 1	0	0	0	380,017	2,058,729	1,806,436	191,773	0	0	0	**4,436,955**	46
WAG	0	0	0	69,370	867,552	232,448	0	0	0	0	**1,169,370**	12
UWS	0	0	0	320,983	1,285,027	662,072	215,957	0	0	0	**2,484,039**	26
Other Public Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Private Funds	0	0	0	0	73,268	1,406,468	133,600	0	0	0	**1,613,336**	17
Total	**0**	**0**	**0**	**770,370**	**4,284,576**	**4,107,424**	**541,330**	**0**	**0**	**0**	**9,703,700**	100
Jobs in Technium Co's	0	0	0	20	20	20	30	47				
Jobs in Technium Support	0	0	4	4	4	4	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	5	0		

Technium 2

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	4,030,020	0	0	0	0	0	0	**4,030,020**	
Revenue	0	0	0	820,320	698,940	737,697	0	0	0	0	**2,256,957**	
Total	**0**	**0**	**0**	**4,850,340**	**698,940**	**737,697**	**0**	**0**	**0**	**0**	**6,286,977**	
Investment												
Obj 1	0	0	0	2,562,120	324,940	361,197	0	0	0	0	**3,248,257**	52
WAG	0	0	0	158,100	158,600	157,300	0	0	0	0	**474,000**	8
UWS	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Public Funds	0	0	0	2,023,120	135,400	139,200	0	0	0	0	**2,297,720**	37
Other Private Funds	0	0	0	80,000	80,000	80,000	0	0	0	0	**240,000**	4
Total	**0**	**0**	**0**	**4,823,340**	**698,940**	**737,697**	**0**	**0**	**0**	**0**	**6,259,977**	100
Jobs in Technium Co's*		0	0	0	0	0	0	0	0	0		
Jobs in Technium Support		0	0	2	2	2	2	2	2	2		
Jobs Technium Graduates		0	0	0	0	0	0	20	45	110		

* Combined with Technium 1

Technium Digital @ Sony

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	0	0	0	500,000	0	0	0	**500,000**	
Revenue	0	0	0	0	0	0	0	0	0	0	**0**	
Total	**0**	**0**	**0**	**0**	**0**	**0**	**500,000**	**0**	**0**	**0**	**500,000**	
Investment												
Obj 1	0	0	0	0	0	0	0	0	0	0	**0**	0
WAG	0	0	0	0	0	0	500,000	0	0	0	**500,000**	100
UWS	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Public Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Private Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**500,000**	**0**	**0**	**0**	**500,000**	100
Jobs in Technium Co's*		0	0	0	0	0	0	9				
Jobs in Technium Support		0	0	0	0	0	0	0	0	0		
Jobs Technium Graduates		0	0	0	0	0	0	0	0	0		

* Combined with Technium 1

Technium Sustainable Technologies

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	96,919	0	1,848,859	4,611,976	72,525	0	0	**6,630,279**	
Revenue	0	0	0	0	0	677,920	704,251	677,469	0	0	**2,059,640**	
Total	**0**	**0**	**0**	**0**	**0**	**2,526,779**	**5,316,227**	**749,994**	**0**	**0**	**8,593,000**	
Investment												
Obj 1	0	0	0	24,670	0	643,172	1,353,204	190,906	0	0	**2,211,952**	25
WAG	0	0	0	72,249	0	1,264,533	2,368,237	285,736	0	0	**3,990,755**	46
UWS	0	0	0	0	0	182,841	193,483	212,635	0	0	**588,959**	7
Other Public Funds	0	0	0	0	0	23,938	1,391,623	50,855	0	0	**1,466,416**	17
Other Private Funds	0	0	0	0	0	412,295	9,680	9,862	0	0	**431,837**	5
Total	**0**	**0**	**0**	**96,919**	**0**	**2,526,779**	**5,316,227**	**749,994**	**0**	**0**	**8,689,919**	100
Jobs in Technium Co's	0	0	0	0	0	0	10	27				
Jobs in Technium Support	0	0	0	0	2	4	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	0	0		

Technium Performance Engineering

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	0	0	4,280,000	1,000,000	0	0	0	**5,280,000**	
Revenue	0	0	0	0	0	1,077,648	1,426,893	1,372,634	0	0	**3,877,175**	
Total	**0**	**0**	**0**	**0**	**0**	**5,357,648**	**2,426,893**	**1,372,634**	**0**	**0**	**9,157,175**	
Investment												
Obj 1	0	0	0	0	0	2,572,659	1,235,523	697,258	0	0	**4,505,440**	49
WAG	0	0	0	0	0	2,458,673	789,820	290,333	0	0	**3,538,826**	39
UWS	0	0	0	0	0	192,906	261,466	243,156	0	0	**697,528**	8
Other Public Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Private Funds	0	0	0	0	0	133,410	140,084	141,887	0	0	**415,381**	5
Total	**0**	**0**	**0**	**0**	**0**	**5,357,648**	**2,426,893**	**1,372,634**	**0**	**0**	**9,157,175**	100
Jobs in Technium Co's	0	0	0	0	0	0	0	0	0	0		
Jobs in Technium Support	0	0	0	0	0	4	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	0	0		

Technium Pembrokeshire

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	0	0	2,339,000	3,815,000	4,354,000	0	0	**10,508,000**	
Revenue	0	0	0	0	0	0	0	0	0	0	**0**	
Total	**0**	**0**	**0**	**0**	**0**	**2,339,000**	**3,815,000**	**4,354,000**	**0**	**0**	**10,508,000**	
Investment												
Obj 1	0	0	0	0	0	463,000	1,644,000	2,096,000	0	0	**4,203,000**	40
WAG	0	0	0	0	0	1,876,000	1,460,000	1,969,000	0	0	**5,305,000**	50
UWS	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Public Funds	0	0	0	0	0	0	711,000	289,000	0	0	**1,000,000**	10
Other Private Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Total	**0**	**0**	**0**	**0**	**0**	**2,339,000**	**3,815,000**	**4,354,000**	**0**	**0**	**10,508,000**	100
Jobs in Technium Co's	0	0	0	0	0	0	0	0	0	0		
Jobs in Technium Support	0	0	0	0	0	0	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	0	0		

N.B. Revenue Project not included!!!

Appendix 7

Impact Assessment

Conservative Model

April 2007

1. Technium Network in South West Wales

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	285,000	1,924,000	0	4,856,893	3,686,596	11,749,993	9,926,976	4,426,525	0	0	**36,855,983**	
Revenue (All Non-Capital Costs)	0	415,500	461,500	860,736	1,296,920	3,318,555	2,672,474	2,050,103	1,265,850	1,305,000	**13,646,638**	
Total	285,000	2,339,500	461,500	5,717,629	4,983,516	15,068,548	12,599,450	6,476,628	1,265,850	1,305,000	**50,502,621**	
Costs (Cumulative)												
Capital	285,000	2,209,000	2,209,000	7,065,893	10,752,489	22,502,482	32,429,458	36,855,983	0	0	**36,855,983**	
Revenue	0	415,500	877,000	1,737,736	3,034,656	6,353,211	9,025,685	11,075,788	0	0	**13,646,638**	
Total	285,000	2,624,500	3,086,000	8,803,629	13,787,145	28,855,693	41,455,143	47,931,771	47,931,771	47,931,771	**50,502,621**	
Investment												
Obj 1	108,000	929,800	184,600	2,966,807	2,383,669	5,846,464	4,424,500	2,984,164	0	0	**19,828,004**	39
WAG	171,000	1,346,700	201,282	299,719	1,026,152	5,988,954	5,118,057	2,545,069	0	0	**16,696,933**	33
UWS	0	57,000	57,000	320,983	1,285,027	1,037,819	670,906	455,791	0	0	**3,884,526**	8
Other Public Funds	0	0	0	2,023,120	135,400	163,138	2,102,623	339,855	1,265,850	1,305,000	**7,334,986**	15
Other Private Funds	6,000	6,000	18,618	80,000	153,268	2,032,173	283,364	151,749	0	0	**2,731,172**	5
Total	285,000	2,339,500	461,500	5,690,629	4,983,516	15,068,548	12,599,450	6,476,628	1,265,850	1,305,000	**50,475,621**	100
Investment (Inflation and STPR adjusted)											**47,744,449**	Public Sector
Total	426,785	3,317,846	623,883	7,295,991	5,957,243	16,901,352	13,287,851	6,476,628	1,190,860	1,155,754	**56,634,194**	
Total	426,785	3,744,632	4,368,514	11,664,505	17,621,749	34,523,101	47,810,951	54,287,579	55,478,440	56,634,194	**56,634,194**	
GDP Deflator (factor) Inflation Deflators*	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948		
Discounting STPR (factor)	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934		

2. Employment and Wages Impact

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Direct Jobs - Companies										
Technium Company Jobs	0	0	0	79	117	166	199	299	450	600
Technium Support Jobs	0	4	8	10	12	18	22	22	22	22
Sub Total (Direct Employment)	0	4	8	89	129	184	221	321	472	622
In-Direct Jobs - Multiplier										
Multiplier (1.25)	0	1	2	22	32	46	55	80	118	156
Total Jobs *(Direct + Multiplier)*	0	5	10	111	161	230	276	401	590	778
Direct Jobs - Graduated Companies										
Jobs in Graduated Companies	0	0	0	0	0	0	0	20	50	110
Multiplier (1.25)	0	0	0	0	0	0	0	5	13	28
Total Jobs (in and beyond network)	0	5	10	111	161	230	276	426	653	915
Impact - Direct										
Average Compensation (£)	20,000	21,000	21,000	21,000	21,000	22,000	23,000	24,000	25,000	26,000
Average Individual Contribution (inc. 22% costs)	24,400	25,620	25,620	25,620	25,620	26,840	28,060	29,280	30,500	31,720
Direct Contribution to Region Employment	0	102,480	204,960	2,280,180	3,304,980	4,938,560	6,201,260	9,984,480	15,921,000	23,219,040
Cumulative of Impact Direct	0	102,480	307,440	2,587,620	5,892,600	10,831,160	17,032,420	27,016,900	42,937,900	66,156,940
Impact - Indirect										
Average Compensation (£)	18,652	19,386	20,062	21,070	21,934	23,093	23,645	24,423	25,320	26,307
Average Individual Contribution (inc. 22% costs)	22,755	23,651	24,475	25,705	26,759	28,173	28,847	29,796	30,890	32,095
Indirect Contribution to Region Employment	0	23,651	48,950	571,945	862,993	1,295,978	1,593,701	2,540,114	4,031,197	5,873,301
Cumulative of Impact (Direct and Indirect)	0	23,651	72,601	644,546	1,507,540	2,803,518	4,397,319	6,937,424	10,968,621	16,841,922
Total Impact (Inflation and STPR adjusted)										
Techium Contribution to Region Employment	0	178,877	343,251	3,639,459	4,982,352	6,992,853	8,220,952	12,524,594	18,770,218	25,765,208
Techium Contribution to Reg Emp (Cum)	0	178,877	522,128	4,161,587	9,143,940	16,136,793	24,357,745	36,882,339	55,652,556	81,417,765
GDP Deflator (factor) Inflation Deflators*	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948
Discounting STPR (factor)	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934

Assumptions
Multiplier (0.5)Indirect & Induced Jobs 0.166666667
Support is included in the Direct Jobs
Multiplier is income coming into the worker monthly
Graduated Jobs count in Economic Output of Technium
Average Salary = £21,000 and incrimental increase per annum

For Chart Prep Only

Direct Impact - Numbers										
Jobs	0	4	8	89	129	184	221	321	472	622
Direct Impact - Value (Inflation and STRP adjusted)										
Cumulative of Impact Direct	0.00	0.15	0.42	3.30	7.04	12.15	17.98	27.02	40.39	58.59
1000000										
Indirect Impact - Numbers										
Jobs	0	1	2	22	32	46	55	85	131	183
Direct Impact - Value (Inflation and STRP adjusted) By Year										
Cumulative of Impact Direct	0.00	0.15	0.28	2.91	3.95	5.54	6.54	9.98	14.98	20.58
1000000										
Indirect Impact										
£	0	0	0	1	1	1	2	3	4	5
1000000										

Total 17

Construction - Employment and Expenditure

Technium 1 (2000)

Factor 0.48

	2000	2001	Total
Total Spend:	2,200,000.00		2,200,000.00
Construction Period: (months)	12.00	3.00	15.00
Average Jobs/Period:	18.65	18.65	18.65
Average Local Jobs:	16.79	16.79	16.79
Average Wage:	27,700.00	27,700.00	27,700.00
Total Wage:	464,998.70	116,249.67	581,248.37
Professional Fees:	129,474.78	32,368.70	161,843.48

Technium 2 (2003)

Factor 0.87

	2002	2003	Total
Total Spend:	4,000,000.00		4,000,000.00
Construction Period: (months)	3.00	12.00	15.00
Average Jobs/Period:	33.91	33.91	33.91
Average Local Jobs:	30.52	30.52	30.52
Average Wage:	27,700.00	27,700.00	27,700.00
Total Wage:	211,363.04	845,452.17	1,056,815.22
Professional Fees:	49,043.48	245,217.39	294,260.87

Technium PE (2006)

Factor 1.13

	2005	2006	Total
Total Spend:	5,200,000.00		5,200,000.00
Construction Period: (months)	12.00	12.00	24.00
Average Jobs/Period:	27.55	27.55	27.55
Average Local Jobs:	24.80	24.80	24.80
Average Wage:	31,537.00	31,537.00	31,537.00
Total Wage:	782,083.32	782,083.32	1,564,166.64
Professional Fees:	191,269.57	191,269.57	382,539.13

Digital Technium (2003)

	2002	2003	Total
Total Spend:	4,600,000.00		4,600,000.00
Construction Period: (months)	3.00	12.00	15.00
Average Jobs/Period:	39.00	39.00	39.00
Average Local Jobs:	35.10	35.10	35.10
Average Wage:	27,700.00	27,700.00	27,700.00
Total Wage:	243,060.00	1,215,300.00	1,458,360.00
Professional Fees:	56,400.00	282,000.00	338,400.00

Factor 1.43

Technium ST (2005)

	2004	2005	Total
Total Spend:	6,600,000.00		6,600,000.00
Construction Period: (months)	6.00	9.00	15.00
Average Jobs/Period:	47.28	47.28	47.28
Average Local Jobs:	42.56	42.56	42.56
Average Wage:	31,537.00	31,537.00	31,537.00
Total Wage:	671,107.36	1,006,661.04	1,677,768.40
Professional Fees:	156,000.00	234,000.00	390,000.00

Technium Energy (2005)

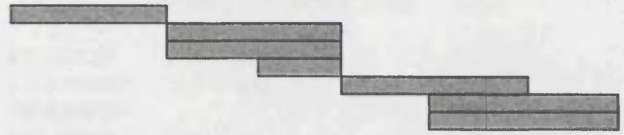
Factor 2.28

	2005	2006	Total
Total Spend:	10,500,000.00		10,500,000.00
Construction Period: (months)	12.00	12.00	24.00
Average Jobs/Period:	55.64	55.64	55.64
Average Local Jobs:	50.07	50.07	50.07
Average Wage:	31,537.00	31,537.00	31,537.00
Total Wage:	1,579,206.71	1,579,206.71	3,158,413.41
Professional Fees:	386,217.39	386,217.39	772,434.78

4. Construction Phase and Fixed Assets*

Year		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008

Technium 1
Digital Technium
Technium 2
Sony
TST
TPE
TE



		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
No. of Jobs Supported											
% of "Local" Jobs		90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Total Local Jobs											
Average Compensation		22,705	22,705	22,705	22,705	22,705	25,850	25,850	25,850	25,850	25,850
Average Individual Contribution (inc. 22% costs)		27,700	27,700	27,700	27,700	27,700	31,537	31,537	31,537	31,537	31,537
Site Operations Contribution (Wages)		0	464,999	116,250	454,424	2,060,752	671,107	3,367,951	2,361,290	0	0
Professional Fees Contribution		0	129,475	32,369	105,443	527,217	156,000	811,487	577,487	0	0
Total Direct Contribution*		0	594,473	148,618	559,867	2,587,970	827,107	4,179,438	2,938,777	0	0
Total Multiplier Contribution (1.25)		0	148,618	37,155	139,967	646,992	206,777	1,044,860	734,694	0	0
Total Construction Contribution		0	743,092	185,773	699,833	3,234,962	1,033,884	5,224,298	3,673,471	0	0

* Totalled from calculations for individual projects on previous page

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Construction Contribution (cum)		0	743,092	928,865	1,628,698	4,863,660	5,897,544	11,121,842	14,795,313	14,795,313	14,795,313

Construction Impact (Inflation and STPR adjusted)

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Construction Contribution		0	1,053,842	251,139	893,023	3,867,040	1,159,637	5,509,739	3,673,471	0	0
Total Construction Contribution (cum)		0	1,053,842	1,304,981	2,198,005	6,065,045	7,224,681	12,734,421	16,407,892	16,407,892	16,407,892
Inflation Deflators*	GDP Deflator (factor)	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948
Discounting	STPR (factor)	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934

Fixed Assets

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Return		0	2,200,000	0	8,600,000	0	6,600,000	15,700,000	0	0	0
Total Return (Cum)		0	2,200,000	2,200,000	10,800,000	10,800,000	17,400,000	33,100,000	33,100,000	33,100,000	33,100,000

Fixed Assets (Inflation and STPR adjusted)

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Return		0	3,120,009	0	10,974,045	0	7,402,765	16,557,806	0	0	0
Total Return (Cum)		0	3,120,009	3,120,009	14,094,055	14,094,055	21,496,820	38,054,626	38,054,626	38,054,626	38,054,626

Construction Phase Chart Prep

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Construction Contribution		0.0	1.1	1.3	2.2	6.1	7.2	12.7	16.4	16.4	16.4

1000000

Non-cumulative employment impacts

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Impact in Year		0.0	1.1	0.3	0.9	3.9	1.2	5.5	3.7	0.0	0.0

1000000

Rental Income - Model and Projections

BUILDING	RENT	PROPERTY (BOOK VALI	Jobs	Rent per Job	
Technium 1	£97,027.00	1,550,000			
Technium 2	£158,005.00	3,100,000			
Technium Swansea	£255,032.00		222	£1,148.79	
Digital Technium	£49,502.00		51	£970.63	
Sustainable Technologies (Baglan)	£29,773.00		31	£960.42	
Performance Engineering (Auto)	£0.00		4		
ECM2	N/A	N/A			
Aberystwyth Technium	£40,050.00		28	£1,430.36	
Optic Technium	£128,110.00		87	£1,472.53	
CAST Technium	£150,000.00		112	£1,339.29	
SONY Digital	£14,100.00		9	£1,566.67	
Pembroke	£0.00		4		
	Total		Total	Overall	
	£921,599		548	£1,681.75	1682

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Rent per Job	£1,428.51	£1,457.40	£1,477.91	£1,512.99	£1,559.79	£1,606.17	£1,650.44	£1,681.75	£1,726.87	£1,773.59
Total Rent	**£0.00**	**£5,829.62**	**£11,823.24**	**£134,655.79**	**£201,212.84**	**£295,535.68**	**£364,746.32**	**£539,841.75**	**£815,083.28**	**£1,103,173.21**
Total Rent NPV (STPR and Inf. Adj)	**£0.00**	**£8,267.48**	**£15,983.35**	**£171,827.76**	**£240,527.75**	**£331,482.01**	**£384,675.09**	**£539,841.75**	**£766,797.28**	**£977,009.30**
Total Rent NPV (STPR and Inf. Adj)	**£0.00**	**£8,267.48**	**£24,250.84**	**£196,078.60**	**£436,606.35**	**£768,088.36**	**£1,152,763.44**	**£1,692,605.19**	**£2,459,402.47**	**£3,436,411.77**
Occupancy	0	4	8	89	129	184	221	321	472	622
Occupancy Adjustment										
Inflation Adjustment	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948
STPR Adjustment	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934

6. Investment Comparison

	Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	Present Value Total 2008
Investment†											
Total		426,785	3,744,632	4,368,514	11,664,505	17,621,749	34,523,101	47,810,951	54,287,579	55,478,440	56,634,194
Employment Contribution†											
Total Return		0	178,877	522,128	4,161,587	9,143,940	16,136,793	24,357,745	36,882,339	55,652,556	81,417,765
Fixed Assets*†											
Total Return		0	1,560,005	1,560,005	7,047,027	7,047,027	10,748,410	19,027,313	19,027,313	19,027,313	19,027,313
Construction Phase†											
Total Return		0	1,053,842	1,304,981	2,198,005	6,065,045	7,224,681	12,734,421	16,407,892	16,407,892	16,407,892
Rental Income											
Total Return		0	8,267	24,251	196,079	436,606	768,088	1,152,763	1,692,605	2,459,402	3,436,412
Total Technium Return											
Total Return		0	2,800,992	3,411,365	13,602,698	22,692,618	34,877,972	57,272,242	74,010,149	93,547,164	120,289,381

NPV	63,655,188
B/C	2.124

* Fixed Assets line assumes building value of 50% of construction cost
† Adjusted in Linked Table for Inflation and STPR (as below)

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Inflation Deflators	GDP Deflator (factor)	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948
Discounting	STPR (factor)	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934

Fixed Assets Chart Prep

Total Return		0.0	1.6	1.6	7.0	7.0	10.7	19.0	19.0	19.0	19.0
1000000											

Technium 1

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	285,000	1,924,000	0	0	0	0	0	0	0	0	2,209,000	
Revenue	0	415,500	461,500	0	0	0	0	0	0	0	877,000	
Total	**285,000**	**2,339,500**	**461,500**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3,086,000**	
Investment												
Obj 1	108,000	929,800	184,600	0	0	0	0	0	0	0	1,222,400	40
WAG	171,000	1,346,700	201,282	0	0	0	0	0	0	0	1,718,982	56
UWS	0	57,000	57,000	0	0	0	0	0	0	0	114,000	4
Other Public Funds	0	0	0	0	0	0	0	0	0	0	0	0
Other Private Funds	6,000	6,000	18,618	0	0	0	0	0	0	0	30,618	1
Total	**285,000**	**2,339,500**	**461,500**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3,086,000**	100
Jobs in Technium Co's	0	0	0	59	97	146	159	216	216	216		
Jobs in Technium Support	4	4	4	4	4	4	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	0	0		

Adjustment figure for previous employment
30

Technium Digital

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	729,954	3,686,596	3,282,134	0	0	0	0	**7,698,684**	
Revenue	0	0	0	40,416	597,980	825,290	541,330	0	0	0	**2,005,016**	
Total	**0**	**0**	**0**	**770,370**	**4,284,576**	**4,107,424**	**541,330**	**0**	**0**	**0**	**9,703,700**	
Investment												
Obj 1	0	0	0	380,017	2,058,729	1,806,436	191,773	0	0	0	**4,436,955**	46
WAG	0	0	0	69,370	867,552	232,448	0	0	0	0	**1,169,370**	12
UWS	0	0	0	320,983	1,285,027	662,072	215,957	0	0	0	**2,484,039**	26
Other Public Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Private Funds	0	0	0	0	73,268	1,406,468	133,600	0	0	0	**1,613,336**	17
Total	**0**	**0**	**0**	**770,370**	**4,284,576**	**4,107,424**	**541,330**	**0**	**0**	**0**	**9,703,700**	100
Jobs in Technium Co's	0	0	0	20	20	20	30	47				
Jobs in Technium Support	0	0	4	4	4	4	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	5	0		

Technium 2

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	4,030,020	0	0	0	0	0	0	**4,030,020**	
Revenue	0	0	0	820,320	698,940	737,697	0	0	0	0	**2,256,957**	
Total	**0**	**0**	**0**	**4,850,340**	**698,940**	**737,697**	**0**	**0**	**0**	**0**	**6,286,977**	
Investment												
Obj 1	0	0	0	2,562,120	324,940	361,197	0	0	0	0	**3,248,257**	52
WAG	0	0	0	158,100	158,600	157,300	0	0	0	0	**474,000**	8
UWS	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Public Funds	0	0	0	2,023,120	135,400	139,200	0	0	0	0	**2,297,720**	37
Other Private Funds	0	0	0	80,000	80,000	80,000	0	0	0	0	**240,000**	4
Total	**0**	**0**	**0**	**4,823,340**	**698,940**	**737,697**	**0**	**0**	**0**	**0**	**6,259,977**	100
Jobs in Technium Co's*		0	0	0	0	0	0	0	0	0		
Jobs in Technium Support		0	0	2	2	2	2	2	2	2		
Jobs Technium Graduates		0	0	0	0	0	0	20	45	110		

* Combined with Technium 1

Technium Digital @ Sony

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	0	0	0	500,000	0	0	0	**500,000**	
Revenue	0	0	0	0	0	0	0	0	0	0	**0**	
Total	**0**	**0**	**0**	**0**	**0**	**0**	**500,000**	**0**	**0**	**0**	**500,000**	
Investment												
Obj 1	0	0	0	0	0	0	0	0	0	0	**0**	0
WAG	0	0	0	0	0	0	500,000	0	0	0	**500,000**	100
UWS	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Public Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Private Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**500,000**	**0**	**0**	**0**	**500,000**	100
Jobs in Technium Co's*		0	0	0	0	0	0	9				
Jobs in Technium Support		0	0	0	0	0	0	0	0	0		
Jobs Technium Graduates		0	0	0	0	0	0	0	0	0		

* Combined with Technium 1

Technium Sustainable Technologies

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	96,919	0	1,848,859	4,611,976	72,525	0	0	**6,630,279**	
Revenue	0	0	0	0	0	677,920	704,251	677,469	0	0	**2,059,640**	
Total	**0**	**0**	**0**	**0**	**0**	**2,526,779**	**5,316,227**	**749,994**	**0**	**0**	**8,593,000**	
Investment												
Obj 1	0	0	0	24,670	0	643,172	1,353,204	190,906	0	0	**2,211,952**	25
WAG	0	0	0	72,249	0	1,264,533	2,368,237	285,736	0	0	**3,990,755**	46
UWS	0	0	0	0	0	182,841	193,483	212,635	0	0	**588,959**	7
Other Public Funds	0	0	0	0	0	23,938	1,391,623	50,855	0	0	**1,466,416**	17
Other Private Funds	0	0	0	0	0	412,295	9,680	9,862	0	0	**431,837**	5
Total	**0**	**0**	**0**	**96,919**	**0**	**2,526,779**	**5,316,227**	**749,994**	**0**	**0**	**8,689,919**	100
Jobs in Technium Co's	0	0	0	0	0	0	10	27				
Jobs in Technium Support	0	0	0	0	2	4	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	0	0		

Technium Performance Engineering

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	0	0	4,280,000	1,000,000	0	0	0	**5,280,000**	
Revenue	0	0	0	0	0	1,077,648	1,426,893	1,372,634	0	0	**3,877,175**	
Total	**0**	**0**	**0**	**0**	**0**	**5,357,648**	**2,426,893**	**1,372,634**	**0**	**0**	**9,157,175**	
Investment												
Obj 1	0	0	0	0	0	2,572,659	1,235,523	697,258	0	0	**4,505,440**	49
WAG	0	0	0	0	0	2,458,673	789,820	290,333	0	0	**3,538,826**	39
UWS	0	0	0	0	0	192,906	261,466	243,156	0	0	**697,528**	8
Other Public Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Private Funds	0	0	0	0	0	133,410	140,084	141,887	0	0	**415,381**	5
Total	**0**	**0**	**0**	**0**	**0**	**5,357,648**	**2,426,893**	**1,372,634**	**0**	**0**	**9,157,175**	100
Jobs in Technium Co's	0	0	0	0	0	0	0	0	0	0		
Jobs in Technium Support	0	0	0	0	0	4	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	0	0		

Technium Pembrokeshire

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	0	0	2,339,000	3,815,000	4,354,000	0	0	**10,508,000**	
Revenue	0	0	0	0	0	0	0	0	0	0	**0**	
Total	**0**	**0**	**0**	**0**	**0**	**2,339,000**	**3,815,000**	**4,354,000**	**0**	**0**	**10,508,000**	
Investment												
Obj 1	0	0	0	0	0	463,000	1,644,000	2,096,000	0	0	**4,203,000**	40
WAG	0	0	0	0	0	1,876,000	1,460,000	1,969,000	0	0	**5,305,000**	50
UWS	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Public Funds	0	0	0	0	0	0	711,000	289,000	0	0	**1,000,000**	10
Other Private Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Total	**0**	**0**	**0**	**0**	**0**	**2,339,000**	**3,815,000**	**4,354,000**	**0**	**0**	**10,508,000**	100
Jobs in Technium Co's	0	0	0	0	0	0	0	0	0	0		
Jobs in Technium Support	0	0	0	0	0	0	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	0	0		

N.B. Revenue Project not included!!!

Appendix 8

Impact Assessment

Optimistic Model

April 2007

1. Technium Network in South West Wales

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	285,000	1,924,000	0	4,856,893	3,686,596	11,749,993	9,926,976	4,426,525	0	0	**36,855,983**	
Revenue (All Non-Capital Costs)	0	415,500	461,500	860,736	1,296,920	3,318,555	2,672,474	2,050,103	1,265,850	1,305,000	**13,646,638**	
Total	285,000	2,339,500	461,500	5,717,629	4,983,516	15,068,548	12,599,450	6,476,628	1,265,850	1,305,000	50,502,621	
Costs (Cumulative)												
Capital	285,000	2,209,000	2,209,000	7,065,893	10,752,489	22,502,482	32,429,458	36,855,983	0	0	**36,855,983**	
Revenue	0	415,500	877,000	1,737,736	3,034,656	6,353,211	9,025,685	11,075,788	0	0	**13,646,638**	
Total	285,000	2,624,500	3,086,000	8,803,629	13,787,145	28,855,693	41,455,143	47,931,771	47,931,771	47,931,771	50,502,621	
Investment												
Obj 1	108,000	929,800	184,600	2,966,807	2,383,669	5,846,464	4,424,500	2,984,164	0	0	**19,828,004**	39
WAG	171,000	1,346,700	201,282	299,719	1,026,152	5,988,954	5,118,057	2,545,069	0	0	**16,696,933**	33
UWS	0	57,000	57,000	320,983	1,285,027	1,037,819	670,906	455,791	0	0	**3,884,526**	8
Other Public Funds	0	0	0	2,023,120	135,400	163,138	2,102,623	339,855	1,265,850	1,305,000	**7,334,986**	15
Other Private Funds	6,000	6,000	18,618	80,000	153,268	2,032,173	283,364	151,749	0	0	**2,731,172**	5
Total	285,000	2,339,500	461,500	5,690,629	4,983,516	15,068,548	12,599,450	6,476,628	1,265,850	1,305,000	50,475,621	100
Investment (Inflation and STPR adjusted)											**47,744,449**	Public Sector
Total	426,785	3,317,846	623,883	7,295,991	5,957,243	16,901,352	13,287,851	6,476,628	1,190,860	1,155,754	**56,634,194**	
Total	426,785	3,744,632	4,368,514	11,664,505	17,621,749	34,523,101	47,810,951	54,287,579	55,478,440	56,634,194	**56,634,194**	
GDP Deflator (factor) Inflation Deflators*	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948		
Discounting STPR (factor)	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934		

2. Employment and Wages Impact

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Direct Jobs - Companies										
Technium Company Jobs	0	0	0	79	117	166	199	299	450	600
Technium Support Jobs	0	4	8	10	12	18	22	22	22	22
Sub Total (Direct Employment)	0	4	8	89	129	184	221	321	472	622
In-Direct Jobs - Multiplier										
Multiplier (1.75)	0	3	6	67	97	138	166	241	354	467
Total Jobs *(Direct + Multiplier)*	0	7	14	156	226	322	387	562	826	1,089
Direct Jobs - Graduated Companies										
Jobs in Graduated Companies	0	0	0	0	0	0	0	20	50	110
Multiplier (1.75)	0	0	0	0	0	0	0	15	38	83
Total Jobs in and beyond network	0	7	14	156	226	322	387	597	914	1,281
Impact - Direct										
Average Compensation (£)	20,000	21,000	21,000	21,000	21,000	22,000	23,000	24,000	25,000	26,000
Average Individual Contribution (inc. 22% costs)	24,400	25,620	25,620	25,620	25,620	26,840	28,060	29,280	30,500	31,720
Direct Contribution to Region Employment	0	102,480	204,960	2,280,180	3,304,980	4,938,560	6,201,260	9,398,880	15,921,000	23,219,040
Cumulative of Impact Direct	0	102,480	307,440	2,587,620	5,892,600	10,831,160	17,032,420	27,016,900	42,937,900	66,156,940
Impact - Indirect										
Average Compensation (£)	18,652	19,386	20,062	21,070	21,934	23,093	23,645	24,423	25,320	26,307
Average Individual Contribution (inc. 22% costs)	22,755	23,651	24,475	25,705	26,759	28,173	28,847	29,796	30,890	32,095
Indirect Contribution to Region Employment	0	70,953	146,851	1,715,835	2,589,180	3,887,937	4,781,374	7,620,342	12,093,592	17,619,902
Cumulative of Impact (Direct and Indirect)	0	70,953	217,804	1,933,639	4,522,819	8,410,556	13,191,930	20,812,272	32,905,864	50,525,766
Total Impact (Inflation and STPR adjusted)										
Techium Contribution to Region Employment	0	245,960	475,599	5,099,123	7,045,578	9,900,074	11,582,696	17,604,822	26,354,991	36,168,415
Techium Contribution to Reg Emp (Cum)	0	245,960	721,559	5,820,681	12,866,260	22,766,334	34,349,029	51,953,852	78,308,843	114,477,258
GDP Deflator (factor) — Inflation Deflators*	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948
Discounting — STPR (factor)	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934

Assumptions
Multiplier (0.5)Indirect & Induced Jobs 0.166666667
Support is Included in the Direct Jobs
Multiplier is income coming into the worker monthly
Graduated Jobs count in Economic Output of Technium
Average Salary = £21,000 and incrimental increase per annum

For Chart Prep Only

Direct Impact - Numbers										
Jobs	0	4	8	89	129	184	221	321	472	622
Direct Impact - Value (Inflation and STRP adjusted)										
Cumulative of Impact Direct	0.00	0.15	0.42	3.30	7.04	12.18	17.96	27.02	40.39	58.59
1000000										
Indirect Impact - Numbers										
Jobs	0	3	6	67	97	138	166	256	392	549
Direct Impact - Value (Inflation and STRP adjusted) By Year										
Cumulative of Impact Direct	0.00	0.15	0.28	2.91	3.95	5.54	6.54	9.98	14.98	20.56
1000000										
Indirect Impact										
£	0	0	0	2	3	4	5	8	11	16
1000000										

Total 50

Construction - Employment and Expenditure

Technium 1 (2000)

Factor 0.48

	2000	2001	Total
Total Spend:	2,200,000.00		2,200,000.00
Construction Period: (months)	12.00	3.00	15.00
Average Jobs/Period:	18.65	18.65	18.65
Average Local Jobs:	16.79	16.79	16.79
Average Wage:	27,700.00	27,700.00	27,700.00
Total Wage:	464,998.70	116,249.67	581,248.37
Professional Fees:	129,474.78	32,368.70	161,843.48

Technium 2 (2003)

Factor 0.87

	2002	2003	Total
Total Spend:	4,000,000.00		4,000,000.00
Construction Period: (months)	3.00	12.00	15.00
Average Jobs/Period:	33.91	33.91	33.91
Average Local Jobs:	30.52	30.52	30.52
Average Wage:	27,700.00	27,700.00	27,700.00
Total Wage:	211,363.04	845,452.17	1,056,815.22
Professional Fees:	49,043.48	245,217.39	294,260.87

Technium PE (2006)

Factor 1.13

	2005	2006	Total
Total Spend:	5,200,000.00		5,200,000.00
Construction Period: (months)	12.00	12.00	24.00
Average Jobs/Period:	27.55	27.55	27.55
Average Local Jobs:	24.80	24.80	24.80
Average Wage:	31,537.00	31,537.00	31,537.00
Total Wage:	782,083.32	782,083.32	1,564,166.64
Professional Fees:	191,269.57	191,269.57	382,539.13

Digital Technium (2003)

	2002	2003	Total
Total Spend:	4,600,000.00		4,600,000.00
Construction Period: (months)	3.00	12.00	15.00
Average Jobs/Period:	39.00	39.00	39.00
Average Local Jobs:	35.10	35.10	35.10
Average Wage:	27,700.00	27,700.00	27,700.00
Total Wage:	243,060.00	1,215,300.00	1,458,360.00
Professional Fees:	56,400.00	282,000.00	338,400.00

Factor 1.43

Technium ST (2005)

	2004	2005	Total
Total Spend:	6,600,000.00		6,600,000.00
Construction Period: (months)	6.00	9.00	15.00
Average Jobs/Period:	47.28	47.28	47.28
Average Local Jobs:	42.56	42.56	42.56
Average Wage:	31,537.00	31,537.00	31,537.00
Total Wage:	671,107.36	1,006,661.04	1,677,768.40
Professional Fees:	156,000.00	234,000.00	390,000.00

Technium Energy (2005)

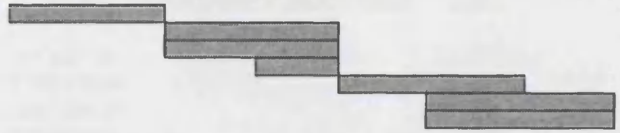
Factor 2.28

	2005	2006	Total
Total Spend:	10,500,000.00		10,500,000.00
Construction Period: (months)	12.00	12.00	24.00
Average Jobs/Period:	55.64	55.64	55.64
Average Local Jobs:	50.07	50.07	50.07
Average Wage:	31,537.00	31,537.00	31,537.00
Total Wage:	1,579,206.71	1,579,206.71	3,158,413.41
Professional Fees:	386,217.39	386,217.39	772,434.78

4. Construction Phase and Fixed Assets*

Year		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008

Technium 1
Digital Technium
Technium 2
Sony
TST
TPE
TE



No. of Jobs Supported										
% of "Local" Jobs	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Total Local Jobs										
Average Compensation	22,705	22,705	22,705	22,705	22,705	25,850	25,850	25,850	25,850	25,850
Average Individual Contribution (inc. 22% costs)	27,700	27,700	27,700	27,700	27,700	31,537	31,537	31,537	31,537	31,537
Site Operations Contribution (Wages)	0	464,999	118,250	454,423	2,060,752	671,107	3,367,951	2,361,290	0	0
Professional Fees Contribution	0	129,475	32,369	105,443	527,217	156,000	811,487	577,487	0	0
Total Direct Contribution*	0	594,473	148,618	559,867	2,587,970	827,107	4,179,438	2,938,777	0	0
Total Multiplier Contribution (1.75)	0	445,855	111,464	419,900	1,940,977	620,331	3,134,579	2,204,083	0	0
Total Construction Contribution	0	1,040,329	260,082	979,766	4,528,947	1,447,438	7,314,017	5,142,860	0	0

* Totalled from calculations for individual projects on previous page

Total Construction Contribution (cum)	0	1,040,329	1,300,411	2,280,177	6,809,124	8,256,562	15,570,578	20,713,438	20,713,438	20,713,438

Construction Impact (Inflation and STPR adjusted)

Total Construction Contribution	0	1,475,379	351,594	1,250,233	5,413,856	1,623,491	7,713,635	5,142,860	0	0
Total Construction Contribution (cum)	0	1,475,379	1,826,974	3,077,206	8,491,063	10,114,554	17,828,189	22,971,049	22,971,049	22,971,049
Inflation Deflators* GDP Deflator (factor)	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948
Discounting STPR (factor)	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934

Fixed Assets

Total Return	0	2,200,000	0	8,600,000	0	6,600,000	15,700,000	0	0	0
Total Return (Cum)	0	2,200,000	2,200,000	10,800,000	10,800,000	17,400,000	33,100,000	33,100,000	33,100,000	33,100,000

Fixed Assets (Inflation and STPR adjusted)

Total Return	0	3,120,009	0	10,974,045	0	7,402,765	16,557,806	0	0	0
Total Return (Cum)	0	3,120,009	3,120,009	14,094,055	14,094,055	21,496,820	38,054,626	38,054,626	38,054,626	38,054,626

Construction Phase Chart Prep

Total Construction Contribution	0.0	1.5	1.8	3.1	8.5	10.1	17.8	23.0	23.0	23.0

1000000

Non-cumulative employment impacts

Impact in Year	0.0	1.5	0.4	1.3	5.4	1.6	7.7	5.1	0.0	0.0

1000000

Rental Income - Model and Projections

BUILDING	RENT	PROPERTY (BOOK VALI	Jobs	Rent per Job
Technium 1	£97,027.00	1,550,000		
Technium 2	£158,005.00	3,100,000		
Technium Swansea	£255,032.00		222	£1,148.79
Digital Technium	£49,502.00		51	£970.63
Sustainable Technologies (Baglan)	£29,773.00		31	£960.42
Performance Engineering (Auto)	£0.00		4	
ECM2	N/A	N/A		
Aberystwyth Technium	£40,050.00		28	£1,430.36
Optic Technium	£128,110.00		87	£1,472.53
CAST Technium	£150,000.00		112	£1,339.29
SONY Digital	£14,100.00		9	£1,566.67
Pembroke	£0.00		4	
	Total		Total	Overall
	£921,599		548	£1,681.75

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Rent per Job	£1,428.51	£1,457.40	£1,477.91	£1,512.99	£1,559.79	£1,606.17	£1,650.44	£1,681.75	£1,726.87	£1,773.59
Total Rent	**£0.00**	**£5,829.62**	**£11,823.24**	**£134,655.79**	**£201,212.84**	**£295,535.68**	**£364,746.32**	**£539,841.75**	**£815,083.28**	**£1,103,173.21**
Total Rent NPV (STPR and Inf. Adj)	**£0.00**	**£8,267.48**	**£15,983.35**	**£171,827.76**	**£240,527.75**	**£331,482.01**	**£384,675.09**	**£539,841.75**	**£766,797.28**	**£977,009.30**
Total Rent NPV (STPR and Inf. Adj)	**£0.00**	**£8,267.48**	**£24,250.84**	**£196,078.60**	**£436,606.35**	**£768,088.36**	**£1,152,763.44**	**£1,692,605.19**	**£2,459,402.47**	**£3,436,411.77**
Occupancy	0	4	8	89	129	184	221	321	472	622
Occupancy Adjustment										
Inflation Adjustment	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948
STPR Adjustment	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934

6. Investment Comparison

	Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	Present Value Total 2008
Investment†											
Total		426,785	3,744,632	4,368,514	11,664,505	17,621,749	34,523,101	47,810,951	54,287,579	55,478,440	56,634,194
Employment Contribution†											
Total Return		0	245,960	721,559	5,820,681	12,866,260	22,766,334	34,349,029	51,953,852	78,308,843	114,477,258
Fixed Assets*†											
Total Return		0	3,120,009	3,120,009	14,094,055	14,094,055	21,496,820	38,054,626	38,054,626	38,054,626	38,054,626
Construction Phase†											
Total Return		0	1,475,379	1,826,974	3,077,206	8,491,063	10,114,554	17,828,189	22,971,049	22,971,049	22,971,049
Rental Income											
Total Return		0	8,267	24,251	196,079	436,606	768,088	1,152,763	1,692,605	2,459,402	3,436,412
Total Technium Return											
Total Return		0	4,849,616	5,692,792	23,188,021	35,887,983	55,145,796	91,384,608	114,672,132	141,793,920	178,939,345

NPV	122,305,151
B/C	3.160

* Fixed Assets line assumes building value of 50% of construction cost
† Adjusted in Linked Table for Inflation and STPR (as below)

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Inflation Deflators	GDP Deflator (factor)	1.177	1.154	1.138	1.112	1.078	1.047	1.019	1.000	0.974	0.948
Discounting	STPR (factor)	1.272	1.229	1.188	1.148	1.109	1.071	1.035	1.000	0.966	0.934

Fixed Assets Chart Prep

Total Return		0.0	3.1	3.1	14.1	14.1	21.5	38.1	38.1	38.1	38.1
1000000											

Technium 1

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	285,000	1,924,000	0	0	0	0	0	0	0	0	**2,209,000**	
Revenue	0	415,500	461,500	0	0	0	0	0	0	0	**877,000**	
Total	**285,000**	**2,339,500**	**461,500**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3,086,000**	
Investment												
Obj 1	108,000	929,800	184,600	0	0	0	0	0	0	0	**1,222,400**	40
WAG	171,000	1,346,700	201,282	0	0	0	0	0	0	0	**1,718,982**	56
UWS	0	57,000	57,000	0	0	0	0	0	0	0	**114,000**	4
Other Public Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Private Funds	6,000	6,000	18,618	0	0	0	0	0	0	0	**30,618**	1
Total	**285,000**	**2,339,500**	**461,500**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3,086,000**	100
Jobs in Technium Co's	0	0	0	59	97	146	159	216	216	216		
Jobs in Technium Support	4	4	4	4	4	4	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	0	0		

Adjustment figure for previous employment
30

Technium Digital

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	729,954	3,686,596	3,282,134	0	0	0	0	**7,698,684**	
Revenue	0	0	0	40,416	597,980	825,290	541,330	0	0	0	**2,005,016**	
Total	**0**	**0**	**0**	**770,370**	**4,284,576**	**4,107,424**	**541,330**	**0**	**0**	**0**	**9,703,700**	
Investment												
Obj 1	0	0	0	380,017	2,058,729	1,806,436	191,773	0	0	0	**4,436,955**	46
WAG	0	0	0	69,370	867,552	232,448	0	0	0	0	**1,169,370**	12
UWS	0	0	0	320,983	1,285,027	662,072	215,957	0	0	0	**2,484,039**	26
Other Public Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Private Funds	0	0	0	0	73,268	1,406,468	133,600	0	0	0	**1,613,336**	17
Total	**0**	**0**	**0**	**770,370**	**4,284,576**	**4,107,424**	**541,330**	**0**	**0**	**0**	**9,703,700**	100
Jobs in Technium Co's	0	0	0	20	20	20	30	47				
Jobs in Technium Support	0	0	4	4	4	4	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	5	0		

Technium 2

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	4,030,020	0	0	0	0	0	0	**4,030,020**	
Revenue	0	0	0	820,320	698,940	737,697	0	0	0	0	**2,256,957**	
Total	**0**	**0**	**0**	**4,850,340**	**698,940**	**737,697**	**0**	**0**	**0**	**0**	**6,286,977**	
Investment												
Obj 1	0	0	0	2,562,120	324,940	361,197	0	0	0	0	**3,248,257**	52
WAG	0	0	0	158,100	158,600	157,300	0	0	0	0	**474,000**	8
UWS	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Public Funds	0	0	0	2,023,120	135,400	139,200	0	0	0	0	**2,297,720**	37
Other Private Funds	0	0	0	80,000	80,000	80,000	0	0	0	0	**240,000**	4
Total	**0**	**0**	**0**	**4,823,340**	**698,940**	**737,697**	**0**	**0**	**0**	**0**	**6,259,977**	100
Jobs in Technium Co's*		0	0	0	0	0	0	0	0	0		
Jobs in Technium Support		0	0	2	2	2	2	2	2	2		
Jobs Technium Graduates		0	0	0	0	0	0	20	45	110		

* Combined with Technium 1

Technium Digital @ Sony

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	0	0	0	500,000	0	0	0	**500,000**	
Revenue	0	0	0	0	0	0	0	0	0	0	**0**	
Total	**0**	**0**	**0**	**0**	**0**	**0**	**500,000**	**0**	**0**	**0**	**500,000**	
Investment												
Obj 1	0	0	0	0	0	0	0	0	0	0	**0**	0
WAG	0	0	0	0	0	0	500,000	0	0	0	**500,000**	100
UWS	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Public Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Private Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**500,000**	**0**	**0**	**0**	**500,000**	100
Jobs in Technium Co's*		0	0	0	0	0	0	9				
Jobs in Technium Support		0	0	0	0	0	0	0	0	0		
Jobs Technium Graduates		0	0	0	0	0	0	0	0	0		

* Combined with Technium 1

Technium Sustainable Technologies

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	96,919	0	1,848,859	4,611,976	72,525	0	0	**6,630,279**	
Revenue	0	0	0	0	0	677,920	704,251	677,469	0	0	**2,059,640**	
Total	**0**	**0**	**0**	**0**	**0**	**2,526,779**	**5,316,227**	**749,994**	**0**	**0**	**8,593,000**	
Investment												
Obj 1	0	0	0	24,670	0	643,172	1,353,204	190,906	0	0	**2,211,952**	25
WAG	0	0	0	72,249	0	1,264,533	2,368,237	285,736	0	0	**3,990,755**	46
UWS	0	0	0	0	0	182,841	193,483	212,635	0	0	**588,959**	7
Other Public Funds	0	0	0	0	0	23,938	1,391,623	50,855	0	0	**1,466,416**	17
Other Private Funds	0	0	0	0	0	412,295	9,680	9,862	0	0	**431,837**	5
Total	**0**	**0**	**0**	**96,919**	**0**	**2,526,779**	**5,316,227**	**749,994**	**0**	**0**	**8,689,919**	100
Jobs in Technium Co's	0	0	0	0	0	0	10	27				
Jobs in Technium Support	0	0	0	0	2	4	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	0	0		

Technium Performance Engineering

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	0	0	4,280,000	1,000,000	0	0	0	**5,280,000**	
Revenue	0	0	0	0	0	1,077,648	1,426,893	1,372,634	0	0	**3,877,175**	
Total	**0**	**0**	**0**	**0**	**0**	**5,357,648**	**2,426,893**	**1,372,634**	**0**	**0**	**9,157,175**	
Investment												
Obj 1	0	0	0	0	0	2,572,659	1,235,523	697,258	0	0	**4,505,440**	49
WAG	0	0	0	0	0	2,458,673	789,820	290,333	0	0	**3,538,826**	39
UWS	0	0	0	0	0	192,906	261,466	243,156	0	0	**697,528**	8
Other Public Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Private Funds	0	0	0	0	0	133,410	140,084	141,887	0	0	**415,381**	5
Total	**0**	**0**	**0**	**0**	**0**	**5,357,648**	**2,426,893**	**1,372,634**	**0**	**0**	**9,157,175**	100
Jobs in Technium Co's	0	0	0	0	0	0	0	0	0	0		
Jobs in Technium Support	0	0	0	0	0	4	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	0	0		

Technium Pembrokeshire

FY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	% of Total
Costs												
Capital	0	0	0	0	0	2,339,000	3,815,000	4,354,000	0	0	**10,508,000**	
Revenue	0	0	0	0	0	0	0	0	0	0	**0**	
Total	**0**	**0**	**0**	**0**	**0**	**2,339,000**	**3,815,000**	**4,354,000**	**0**	**0**	**10,508,000**	
Investment												
Obj 1	0	0	0	0	0	463,000	1,644,000	2,096,000	0	0	**4,203,000**	40
WAG	0	0	0	0	0	1,876,000	1,460,000	1,969,000	0	0	**5,305,000**	50
UWS	0	0	0	0	0	0	0	0	0	0	**0**	0
Other Public Funds	0	0	0	0	0	0	711,000	289,000	0	0	**1,000,000**	10
Other Private Funds	0	0	0	0	0	0	0	0	0	0	**0**	0
Total	**0**	**0**	**0**	**0**	**0**	**2,339,000**	**3,815,000**	**4,354,000**	**0**	**0**	**10,508,000**	100
Jobs in Technium Co's	0	0	0	0	0	0	0	0	0	0		
Jobs in Technium Support	0	0	0	0	0	0	4	4	4	4		
Jobs Technium Graduates	0	0	0	0	0	0	0	0	0	0		

N.B. Revenue Project not included!!!

Appendix 9 Technium Company Survey Questionnaire

Technium®
Abertawe
Swansea

TECHNIUM BUSINESS REVIEW

Objectives of the Review Questionnaire

1.	Update on progress of business
2.	Level of support obtained over review period
3.	Obtain statistics for monitoring Technium concept
4.	Identify areas for improvement

Company Name:	
Completed by:	
Date completed:	

Thank you for providing your time to complete this review. To help you in doing so please bear in mind the following;

Guidance for Completion of Questionnaire:

- All information is confidential and will be only used in an aggregated format. If you would like to discuss any issue in more detail please give an indication in the relevant section.

- Please complete sections as fully as possible, including any relevant quantitative data.

- For questions relating to satisfaction or frequency of usage please use the following scales:

  Satisfaction: Complete satisfaction, mostly satisfied, indifferent, mostly dissatisfied, completely dissatisfied
  Frequency: Everyday, twice a week plus, weekly, infrequently/monthly, never

- Please feel free to include any other information which you feel may be relative or informative.

- If you are unsure about answering any questions, or for any other comment or query, please do not hesitate to contact Gareth Davies using the contact details on the last page.

Many thanks,

The Research Team

1. COMPANY PROFILE AND DEVELOPMENT

Company Name			
Company Address			
	Postcode		
Tel		Fax	
Email		Web site	
Contact Name		Title	
Business Type			
Date company established			
Date company moved to Technium			
Turnover on entry to Technium			

Company type on entry to Technium? (please tick)

Spin out		Entrepreneur		SME		Inward Investment	

Which of the following sectors were the company founders from? (please tick all appropriate responses)

Academia		Industry		Other	

How many new companies have the founders been involved with in the past? (number)

5 years		10 years		

What proportion of company founders fall into the following age groups? (please indicate percentages)

<25 years		25 – 55 years		55 years +	

What stage is your company in?	Start-up		Early Growth		Late-growth / Maturing	
What did you enter Technium with?	Idea		Prototype		Product	

Has the company achieved and does it in the future intend to achieve the following?
(Please add any detail, particularly quantitatively where appropriate)

	2001/2	2002/3	2003/4	2004/5	2005/6	2006/7
Bus Plan objectives achieved						
New projects						
New products / services						
New business started						
Awards obtained						
Certification/Accreditation						
Turnover p.a.						

What percentage of turnover relates to the following markets?

In Wales		In the UK		Overseas	

How do you see this changing as the company develops? (e.g. changing of above)

What percentage of your customers fall in the following categories?

End-users (direct)		End-users (via distributors)		Other company which adds value	

Where do you find the following? (please give percentages for all appropriate responses)				
	Technium	**Wales**	**UK**	**World**
R&D Partners				
Suppliers – low tech.				
Suppliers – high tech.				
Customers				
ICT Services				

Do you plan future relocation? (Y/N)		Please give details below			
Technium 2 (if applicable)		**Elsewhere** (please state)		**Space requirement**	

What do you estimate company value as at the following intervals?			On entering Technium		
Now		5 years time		10 years time	

2. INNOVATION

Do you generate and/or protect IP? (Y/N)			
Generate		Protect	

What type(s) of IP do you generate? (please tick all appropriate responses)									
Patents		Copyright		Trademarks		Trade Secrets		Know-How	

What proportion of employees are involved in IP creation / R&D? (%)	
Do you licence in technology? (Y/N)	

Do you collaborate in innovation with other companies in any of the following areas? (please tick all appropriate responses)							
Technium		Wales		UK		Global	
SMEs		Large		Multinationals			

Please give details of any collaboration you have with other Technium companies	
Have you collaborated with any Welsh universities in innovation? (Y/N)	
If so, please give details	

Please indicate what your innovation is driven by: (please tick as appropriate)		
In-house developments		
Response to specific customer needs		
Ad-hoc improvements allowed by technology		
Maintaining/gaining competitive advantage		

3. COMPANY EMPLOYMENT AND NETWORKING PROFILE

Please indicate the number of employees in each of the following categories:

Staff type	**2001**		**2002**		**2003**		**2004**		**2005**		**2006**		**2007**		**2008**	
	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
Admin																
R&D/ High-tech																
Management																
Manufacturing																
Other																

Please provide a breakdown of the number of jobs created by salary;

£8500-£11499		£11500-£15499		£15500-£18999		£19000-£23999		£24000-£28999	
£29000-£33499		£33500-£38499		£38500-£43499		£43500-£48499		£48500+	

Out of those listed above, how many were recruited as graduates? (number)

Before joining Technium		After joining Technium	

What graduate skills do you have in the company? (please tick)

Sciences		Engineering		Business		Other	

Are these skills? (please tick)

Fundamental		Indifferent		A hindrance	

What proportion of the graduates relate to the following? (%)

Graduated in Wales		Hold a post-graduate qualification	

What is the average salary in the following areas if your company?

R&D		Management		Admin		Overall	

What are your total annual payroll costs?		

What percentage of staff are;

	Female?		Of ethnic origin?	

Please give brief details of any training undertaken or planned by the company in the following categories:

	To date	**Planned**
Administrative		
R&D/High-tech		
Management		
Other		

4. Networking Activity (i.e. Seminars, events, collaborations, WWCC, DTI)			
Have you networked through any if the following? (please indicate frequency)	**2003**	**2004**	**2005**
West Wales Chamber of Commerce			
WAG/WDA technology events			
Regional Sectoral fora			
Trade Associations			
Trade Exhibitions			
Informal Sales networks			
Informal R&D networks			
Regional Partnerships (City and County etc.)			

How frequently do you network in the following areas?(please indicate on scales 5 for often to 1 for rarely)							
In Technium		Wales		UK		Global	

Does Technium help you to network with any of the following? (please tick)		**If so, how often do you network with them?** (please indicate on scales 5 for often to 1 for rarely)
Other Technium Companies		
Other Technology companies (SME)s		
Other Technology companies – large		
Potential Investors/Financers		
Other organisations		

5. FINANCE AND SUPPORT

Where did the company gain the majority of initial funding from? (please include appropriate percentages)

Government Grants		Founders funds		Angel Investment		Parent company	
Other (please specify)		Bank Loans					

Has the company since attracted funding from any of the following? (please tick all appropriate responses)

Government Grants		Angel Investors		Venture Capitalist		Commercial Partners	

Please list any public sector financing attracted by the company (e.g. RSA, SMART grants, KTP projects etc.)

6. BUSINESS SUPPORT

Have you received any of the following public support?
(Please give any relevant details, such as the provider)

	(Y/N)		(please describe support provided)
Business start-up support		Details	
Financing advice		Details	
Financing (e.g. grants)		Details	
Legal Advice (e.g. IP advice)		Details	
HR Support (e.g. recruitment)		Details	
Marketing (e.g. trade missions)		Details	
Other support		Details	

Have you received any of the following private support?
(Please give any relevant details, such as the provider)

	(Y/N)		(please describe support provided)
Business start-up support		Details	
Financing advice		Details	
Financing (e.g. grants)		Details	
Legal Advice (e.g. IP advice)		Details	
HR Support (e.g. recruitment)		Details	
Marketing (e.g. trade missions)		Details	
Other support		Details	

Has being in Technium directly or indirectly helped you to attract finance or support? (Y/N)
(e.g. brand association, developing partnerships, etc.)

If so, please give details:

7. TECHNIUM SUPPORT

ave you benefited from WAG/WDA support? (Y/N)	
so, please give details:	

ithout Technium, when and where would the company have most likely been established?

ooner		Same time		Later/Not at all	
Wales		Elsewhere		Not at all	

ow do you believe Technium has affected the development of your business to the present? (please tick)

ery ositively		Positively		No differently		Negatively		Very Negatively	

ow do you believe Technium will affect the development of your business in the future? (please tick)

ery ositively		Positively		No differently		Negatively		Very Negatively	

ease give details if appropriate:

id you expect to find/actually find that Technium assisted (directly/indirectly) in the following areas and as this added value to your business? (please indicate Y/N and give details)

	Expected to Find	Actually Found	Added Value
siness Operations			
eveloping collaborations ndustrial)			
eveloping collaborations cademic)			
arketing / Accessing markets			
anagement			
ccessing facilities			
tracting Finance			

ease indicate how often you use the following facilities (everyday, twice weekly, weekly, monthly, frequently, never) **and assess their quality** (5 best to 1 worst):

acility	**Frequency of Use**	**Quality**									
eception		5		4		3		2		1	
otice /display area		5		4		3		2		1	
axing facilities		5		4		3		2		1	
hotocopying facilities		5		4		3		2		1	
itchen area		5		4		3		2		1	
eeting room		5		4		3		2		1	
onference room		5		4		3		2		1	
ideo conference		5		4		3		2		1	
onference Room		5		4		3		2		1	
ar parking		5		4		3		2		1	
hour access		5		4		3		2		1	
uffet Service		5		4		3		2		1	
ecurity		5		4		3		2		1	
elephony Support		5		4		3		2		1	
elecommunications frastructure		5		4		3		2		1	
ternet Access		5		4		3		2		1	

8. FUTURE TECHNIUM DEVELOPMENTS

Technium is considering the possibility of providing certain services on the VPN and would like feedback as to whether tenants would be interested in their provision. Please indicate below interest in the following;

ICT Support

What expectations do you have of the ICT support currently supplied by Technium?					
How would you like to see this support expanded/changed/delivered in future?					
Would you have specific interest in the following?					
Service delivery through a single point of contact					
Issue tracking system for enquiries (e.g. reference numbers)					
Hardware advice;	Pre-procurement?		Post-procurement?		
Would you prefer delivery of service through;			Web?		Phone?

Data Systems

What expectations do you have of the data services currently supplied by Technium?	
How would you like to see these facilities and services expanded/changed/delivered in future?	
Would you have specific interest in the following?	
Central Resilient Storage	
Increased bandwidth	
Secure data connectivity	
Resilient data connectivity	
Email/Virus filtering	
Hosting	

VPN functionality

What expectations do you have of the VPN currently supplied by Technium?	
How would you like to see the services delivered over the VPN developed and added to in future?	
Would you have specific interest in the following?	
Web presence	
Customer contact management	
Market insight information	

Telephony

What expectations do you have of the telephony services currently supplied by Technium?	
How would you like to see these services expanded/changed in future?	
Would you have specific interest in the following?	
VOIP telephony	
VOIP overseas telephone presence	
Call breakdown for CRM purposes	
Local Videoconferencing	
Call centre facilities	

Please suggest any additional tools which you would like to be considered or comments you may have:

9. POTENTIAL IMPROVEMENTS

Please give details of the following areas and describe any additional support or areas for improvement that could assist you in developing your business.

Business Support

Level of Business Support currently provided:	
Additional Business Support required:	

Technium Facilities

Level of Technium Facilities currently provided:	
Additional Technium Facilities required:	

Please make any other comments and list any ideas for improvement:

Completion date		Signed by company	

Many thanks for your time in completing this questionnaire. Your time is greatly appreciated.

Please return electronically to:

[illegible].h.davies@swansea.ac.uk

Or by post to:

Knowledge Economy Research Group
107 Digital Technium
Swansea University
Singleton Park
Swansea
SA2 8PP

Tel: 01792 513752
Fax: 01792 295620

Appendix 10 Comparison Group Survey Questionnaire

WELSH TECHNOLOGY COMPANY BUSINESS REVIEW

Company Name:	
Completed by:	
Date completed:	

Thank you for taking your time to complete this review. To help you in doing so please keep in mind the following;

Guidance for Completion of Questionnaire:

- All information is confidential and will be only used in an aggregated format. If you would like to discuss any issue in more detail please give an indication in the relevant section. Further, if there is any question which you feel inappropriate please leave it blank and move to the next question.

- Please complete sections as fully as possible, including any relevant quantitative data.

- For questions relating to satisfaction or frequency of usage please use the following scales:

  Satisfaction: Complete satisfaction, mostly satisfied, indifferent, mostly dissatisfied, completely satisfied
  Frequency: Everyday, Twice a week plus, Weekly, infrequently/monthly, never

- Please feel free to include any other information which you feel may be relative or informative.

- If you are unsure about answering any questions, or for any other comment or query, please do not hesitate to contact the research team using the contact details on the final page.

Many thanks, the Research Team

1. COMPANY PROFILE AND DEVELOPMENT

Company Address:			
	Postcode:		
Tel:		**Fax:**	
Email:		**Web site**	
Contact Name:		**Title:**	
Business Type			

Date **company established**	

Is your company in (please tick) | Start-up | | Early Growth | | Late-growth / Maturing | |

Has the company achieved and does it in the future intend to achieve the following;
(Please add any detail, particularly quantitatively where appropriate)

	2001/2	2002/3	2003/4	2004/5	2005/6	2006/7
New products / services						
Turnover p.a.						

What percentage of turnover relates to markets? (%)

In Wales		In the UK		Overseas	

How do you see this changing as the company develops? (e.g. change in percentages)

Are your customers? (please add any % breakdown)

End-users (direct)		End-users (via distributors)		Other company which adds value	

Where do you find the following? (please tick all appropriate responses)

	Wales	UK	World
R&D Partners			
Suppliers – low tech.			
Suppliers – High tech.			
Customers			
ICT Services			

Do you generate / protect IP? (please tick and elaborate if you wish)

Generate		Protect	

What type(s) of IP do you generate? (please tick)

Patents		Copyright		Trademarks		Trade Secrets		Know-How	

What proportion of employees are involved in IP creation / R&D? (%)

Do you innovate with other companies in; (please tick all appropriate responses)

		Wales		UK		Global	
SMEs		Large		Multinationals			

Have you collaborated with any Welsh universities in innovation?

If so, how?	

Is your innovation driven by;

In-house developments		
Response to specific customer needs		
Ad-hoc improvements allowed by technology		
Maintaining/gaining competitive advantage		

Staffing	2001		2002		2003		2004		2005		2006		2007		2008	
	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
Number																

Out of those listed above, what proportion are graduates?							
What graduate skills do you have in the company?							
Sciences		Engineering		Business		Other	
What skills do you have most difficulty in recruiting?							

3. Networking Activity (i.e. Seminars, events, collaborations, WWCC, DTI)			
Have you networked; (please indicate frequency)	**2003**	**2004**	**2005**
West Wales Chamber of Commerce			
WAG/WDA technology events			
Regional Sectoral fora			
Trade Associations			
Trade Exhibitions			
Informal Sales networks			
Informal R&D networks			
Regional Partnerships (City and County etc.)			

Where do you network (please indicate on scales 5 for often to 1 for rarely)					
Wales		UK		Global	

4. FINANCE AND SUPPORT							
Did the company start with the majority of funding from;							
Government Grants		Founders funds		Angel Investment		Parent company	
Other		Bank Loans					
Has the company since its start attracted funding from;							
Government Grants		Angel Investors		Venture Capitalist		Commercial Partners	
Please list any public sector financing attracted by the company (e.g. RSA, SMART grants, KTP projects etc.)							

5. Business support			
Public/Private Sector – Have you received any support in any of the following? (Please give any relevant details, such as the provider, quality etc.)			
Public and/or Private (please indicate)		**Details**	
Business start-up support			
Financing advice			
Financing (e.g. grants)			
Legal Advice (e.g. IP advice)			
HR Support (e.g. recruitment)			
Marketing (e.g. trade missions)			
Other support			

Please feel free to provide any other comments or information that may be of interest to the review regarding support available to or challenges facing technology companies in Wales.

Completion date		Signed by company	

Many thanks for your time in completing this questionnaire. Your time is greatly appreciated.

Please return electronically to: g.h.davies@swansea.ac.uk

Or by post to:

Knowledge Economy Research Group
107 Digital Technium
Swansea University
Singleton Park
Swansea
SA2 8PP

Tel: 01792 513752
Fax: 01792 295620

Appendix 11

Knowledge Enterprise Comparisons

1. Turnover Growth

Control Group Companies

	Turnover p.a. 2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	Av Turn.	Annual Growth Rates 2002/03	2003/04	2004/05	2005/06
1	150,000	200,000	300,000	450,000	550,000	600,000	375,000	33	50	50	22
2				350,000	450,000	800,000	266,667				29
3	791,000	1,057,000	1,051,000	1,193,000	980,000	1,150,000	1,037,000	34	-1	14	-18
4											
5					800,000		133,333				
6	168,000	178,000	180,000	156,000	142,000	150,000	162,333	6	1	-13	-9
7			80,000	120,000	150,000		58,333			50	25
8											
9											
10					100,000	150,000	41,667				
11											
12		9,000	16,000	17,000	28,000	40,000	22,000		78	6	65
13	547,140	682,205	1,006,636	1,144,734	1,340,000		786,786	25	48	14	17
14	150,000	200,000	300,000	450,000	550,000	600,000	375,000	33	50	50	22
15											
16											
17	785,165	796,604	663,107	519,632	528,819	700,000	665,555	1	-17	-22	2
18	280,000	350,000	370,000	330,000	450,000	480,000	376,667	25	6	-11	36
19	35,000	55,000	40,000	22,000	55,000		34,500	57	-27	-45	150
20											
21	100,000	115,000	88,000	100,000	120,000	115,000	106,333	15	-23	14	20
22	140,000	120,000	140,000	140,000	140,000	140,000	136,667	-14	17	0	0
23	80,000	95,000	104,000	104,000	104,000	104,000	98,500	19	9	0	0
24	65,000	90,000	243,000	265,000	244,000	256,000	193,833	38	170	9	-8
25	160,000	165,000	140,000	162,000	155,000	160,000	157,000	3	-15	16	-4
All	2,869,165	3,366,604	3,579,107	3,869,632	3,963,819	4,455,000	3,683,888	17	6	8	2
Av Increase		50,193	37,781	30,108	28,966	64,513					
	Entries	90			Av. Turnover (All)		334,900				
St. Dev.	254,790	306,858	321,006	345,485	352,420	323,658					

Technium Companies

	Turnover p.a.							Annual Growth Rates			
	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07		2002/03	2003/04	2004/05	2005/06
1											
2											
3					180,000	500,000	340,000				
4											
5	37,000	37,000	39,000	53,000			41,500	0	5	36	
6					120,000	180,000	150,000				
7											
8				1,300,000	3,000,000	7,000,000	3,766,667				131
9			35,000	75,000	135,000	220,000	116,250				
10	200,000	275,000	500,000	450,000	500,000		385,000	38	82	-10	11
11		301,787	183,147	335,000	665,000	1,052,000	507,387			83	99
12	900,000	1,000,000	1,150,000	1,350,000	1,500,000	2,000,000	1,316,667	11	15	17	11
13		805,000	1,165,000	1,000,000	1,300,000		854,000		45	-14	30
14	100,000	100,000	558,000	1,000,000	1,400,000		631,600	0	458	79	40
15	420,000	500,000	550,000	499,130	507,623		495,351	19	10	-9	2
16											
17	72,000	74,000	157,000	364,000	498,000	600,000	294,167	3	112	132	37
18											
19				100,000	100,000	150,000	116,667				0
20				40,000	40,000	80,000	53,333				0
21					59,000	63,693	61,347				
22					60,000	125,000	92,500				
23	56,500	177,000	222,000	216,024	337,000	500,000	251,421	213	25	-3	56
All	1,785,500	3,269,787	4,559,147	6,782,154	10,401,623	12,470,693	6,544,817	83	39	49	53
Av Increase		53,929	139,373	78,301	271,122	481,391					
	Entries	67				Av. Turnover (All)	£586,103				
St. Dev.	290,496	320,582	396,892	458,868	771,892	1,873,860					
Chart Prep	01/02	02/03	03/04	04/05	05/06	06/07					
Av Increase excl Cyden		53,929	139,373	78,301	141,224	161,518					

2006/07	Av. Ann. Growth	Tur. Weight	Av. Ann. Growth	Inn. Emp
9	33	1.119736	33	10
78	53	0.796256	53	70
17	9	3.096442	9	25
6	-2	0.484721	-2	5
	38	0.174181	38	50
50	50	0.124415	50	50
43	48	0.065691	48	30
	21	2.349312	21	7
9	33	1.119736	33	10
32	-1	1.98732	-1	40
7	13	1.124712	13	20
	34	0.103016	34	50
-4	4	0.317507	4	50
0	0	0.408081	0	66
0	6	0.294117	6	50
5	43	0.578779	43	60
3	1	0.468796	1	50
12	9			

Correlation -0.27269
0.074361
-0.27269

2006/07	Av. Ann. Growth	Turn. Weight	Av. Ann. Growth	Inn. Emp	Av ann. Growth		Company Inv.
						1	
178	178	0.58	178	80	177.78		4
			0	100			
	14	0.07	14	50	13.77		2
50	50	0.26				1	
133	132	6.43	132	30	132.05		6
63	63	0.20	63	20			
	24	0.66	24	100	24.09		1
58	80	0.87	80	75			
33	18	2.25			18		4
	20	1.46	20	20	20.19		3
	144	1.08	144	40	144.30		3
	5	0.85	5	70	5.38		1
			0	80		1	
20	61	0.50	61	85	60.82	1	4
						1	
50	25	0.20	25	100			
100	50	0.09	50	100			
8	8	0.10	8	100			
108	108	0.16	108	100			
48	68	0.43					
20	49						

Correlation 0.303273
0.091975

Correlation	0.595239
	0.354309

Employment Growth

Control Group Companies

	FTEs* (Total) 2001	2002	2003	2004	2005	2006	2007	Increase	Unchanged	Decrease	How many are graduates%	Absolute Graduates
1											20	
2											80	
3	0	0	0	0	0	17.5	19.5	1				
4	2.5	2.5	2.5	2.5	3	2.5	3		1		0	0
5	10	10	12	18	17.5	17	17	1			100	17
6	65	65	58	55.5	55.5	46	44			1	5	2.2
7	1	1	1	1	3	3	3	1			100	3
8	0	0	0	0	2.5	2.5	2.5		1		79	1.975
9												
10	0	0	0	0	2	2	3	1				0
11	0	0	3	3	2.5	2	2			1	0	0
12	0.5	0.5	0.5	0.5	0.5	0.5	0.5		1		100	0.5
13	3	4.5	7.5	9.5	10.5	14	16	1				0
14											20	
15											40	
16											0	
17	23	22	19	19	14	19	20			1	90	18
18	0	47	48	47	51	52	54	1				0
19	2	2	2	2	2	2	2		1		50	1
20	0	0	0	0	0	12.5	12.5		1		30	3.75
21	2.5	2.5	2.5	2.5	2.5	2.5	2.5		1		30	0.75
22	2	1	2	1.5	3	1.5	3	1			100	3
23	1	0.5	1	0.5	1	0.5	1		1		50	0.5
24	2	1.5	3.5	2.5	3.5	2.5	4	1			50	2
25	1	0.5	1	0.5	1	0.5	1		1		50	0.5
All	115.5	160.5	163.5	165.5	175	200	210.5	8	8	3	Average 49.7	3.00972222

Median 50

Total 19

42.10526 42.10526316 15.789474

Average 10.52632

St Dev 14.63995

St Dev 35.75206288

No Grads 15

Average - without biggest two 6

Technium Companies

	FTEs* (Total) 2001	2002	2003	2004	2005	2006	2007	Increase	Unchanged	Decrease	% who are graduates	Absolute Graduates
1	0	0	0	3	3	4	4	1			50	2
2	0	0	2.5	3.5	4	5	5	1			80	4
3	0	0	0	0	3	6.5	8	1			72	5.76
4	1.5	1.5	1.5	1.5	2.5	2.5	4	1			50	2
5	4	4	4	3	4	5.5	7	1			100	7
6	0	0	0	0	0	3	5	1			100	5
7	0	0	0	0	0	1	1		1		100	1
8	0	4	4	10	23	33	46	1			88	40.48
9	0	0	0	0	0	0	7	1			100	7
10	2	6	6	5	6	7	7	1			75	5.25
11	0	0	0	0	12.5	13.5	0	1			100	0
12	20	21	24	25	26	25	0	1			72	0
13	2	6	6	6	7	7	9	1			71	6.39
14	3.5	6.5	9	12	17	25	0	1			88	0
15	3	5	9	11	13	14	0	1			43	0
16	0	0	0	2	3	4	8	1			75	6
17	3	5	6	10	13	15	16	1			66	10.56
18	0	0	0	2	2	5	8	1			100	8
19	0	0	0	2	3	3.5	3.5	1			100	3.5
20	0	0	0	1	1	1	2	1				
21	2	2	2	2	3	4	7	1			100	7
22	0	0	0	2	3	3	4	1			100	4
23	3	5	6	9	10	8	12	1				
All	44	66	80	110	159	195.5	163.5	22	1	0	Average 82.38095238	5.94952381

Median 88

Total 23

95.65217 4.347826087 0 St Dev 18.55872581

Average 8.5

St Dev 8.473745

7.386364

Innovation

Control Group Companies

Ref	Does the company? Generate IP	Protect IP	Types of IP: Patents	Copyright	Trademarks	Trade Secrets	Know-How	% employees engaged in R&D/Innovation	Do you collaborate in innovation with companies from:	Wales	UK	Global	SMEs	Large	Multi-nationals	Collaboration with welsh universities: Y/N	How	Innovation driven by: In-house dev	Respond to cust. Needs	Ad-hoc Imp. With tech	maintain/gain comp adv
Total	19	13	7	11	7	5	17	Average 48.1304348	0	14	17	6	14	6	6	10	0	18	17	10	12
Average	76	52	28	44	28	20	68 %	28.4686011	0	56	68	24	56	24	24	40	0	72	68	40	48

New Products / Services	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Total	8	12	12	11	14	15
% of companies	32	48	48	44	56	60

Patents	Patents	Post 2000	Post 2000 citations
Helen Mon	0	0	0
Draig Technology	0	0	0
Aber			
Instruments	2	1	1
Balck Dragon Crafts	0	0	0
CRG Research Ltd	0	0	0
Illustrated Stationery Ltd.	0	0	0
Neem Biotech Ltd	2	2	0
Reynolds Geo-Sciences Ltd	0	0	0
Quocom Ltd	0	0	0
BlueBay Software Limited	0	0	0
F G M International Ltd.	0	0	0
Lushlee Ltd (The VideoBooth)	0	0	0
Reid Lifting Limited	1	1	0
Seasalt	0	0	0
Biocatalysts Ltd	0	0	0
Bluelake Technology	0	0	0
Imaginet Ltd	0	0	0
The Magstim Company Limited	6	3	0
reMODEL Consultants Intl	0	0	0
Smoke Control Services Ltd	0	0	0
Kaiak Ltd.	0	0	0
Conwy Valley Systems	0	0	0
Trainer Electronics Ltd	0	0	0
Live Solutions	0	0	0
Cyfrus	0	0	0

Wider Group Analysis

Average Holding	Maximum Holding	Average Citations
1.96	9	0.31

Technium Companies

Ref	Does the company? Generate IP	Protect IP	Licence IP	Types of IP generated: Patents	Copyright	Trademarks	Trade Secrets	Know-How	% employees engaged in R&D	Do you collaborate in innovation with companies from: Technium	Wales	UK	Global	SMEs	Large	Multi-nationals	Technium collab details: Y/N	How	Collaboration with welsh universities: Y/N	How	Innovation driven by: In-house dev	Respond to cust. Needs	Ad-hoc Imp. With tech	maintain gain comp adv
Total	19	9	11	9	15	11	5	10	Average 73.80952381	14	13	18	9	10	5	7	14	0	17	0	18	20	16	20
Average	83	56	65	39	66	48	22	43 %	28.57341263	60.8695652	56.52174	78.26087	56.25	66.66667	33.33333	43.75	60.86956522	0	73.91304	0	78.26087	86.95652	69.56522	86.95652

Chart Prep							
Comp Group	0	56	68	24	56	24	24
Technim Co.	61	57	78	56	67	33	44

Chart Prep	In-house dev	Response to customer needs	Ad-hoc improvement with technology	maintain gain competitive advantage
Comp Group	72	68	40	48
Tech Comp	78	87	70	87

New Products / Services	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Total	3	6	10	9	14	12
% of companies	25	46.15385	76.92308	69.23077	87.5	75

Chart Prep	05/06	06/07
Comp Gr	56	60
Tech Co	87.5	75

	Patents	Post 2000	Post 2000 citations
Vishay Siliconix	10	10	3
Waters Designs Ltd	0	0	0
XL Imaging	0	0	0
Jane IT Systems Ltd	0	0	0
Quantum Prospecting	0	0	0
Laing O'Rourke Dev Centre	8	8	0
Chygwyn*	0	0	0
Cy Den Ltd	5	5	0
Icreate	0	0	0
Imagitech	0	0	0
RAP International	1	1	0
Rockfield Software	0	0	0
High Torque Fasteners Ltd	0	0	0
Dezrez	0	0	0
S6060	0	0	0
Golden Prosperity Ltd	0	0	0
ACS Environmental			
Npower			
S ERS			
UniGryw			
Map Analysis			
Haz Res			
Netalogue			
# companies	4		

Wider Group Analysis

Average Holding	Maximum Holding	Average Citations
4.44	11	1.33

Networking

Control Group Companies

	Frequency of Networking			
	Technium	Wales	UK	Globally
1				
2		5	3	1
3		3	3	4
4		4	3	3
5		4	3	1
6		1	1	1
7				3
8		5	5	3
9		2	5	2
10		1		
11		3	3	1
12		3	1	1
13		5	3	1
14		3	5	4
15		4	3	3
16		3	4	1
17		3	1	1
18		5	3	2
19		1	1	1
20		4	4	1
21				
22		2	3	2
23		3	4	1
24		4	1	2
25		5	4	1
Average	0	3.318182	3	1.818182

Technium Companies

	Frequency of Networking			
	Technium	Wales	UK	Globally
1	3	4	2	5
2	5	5	3	1
3	1	1	2	3
4	3	4	3	1
5	3	3	4	3
6	5	3	4	4
7				
8	1	2	1	5
9	3	4	1	
10	2	5	2	
11			4	5
12			5	5
13	1	3	4	3
14	3	2	2	
15	3	4	2	
16			1	1
17	3	5	4	3
18	3	4	4	4
19	4	4	4	4
20	3	5	4	2
21	4	4	3	2
22	4	4	4	4
23	2	3	5	4
	2.94736842	3.631579	3.090909	3.277778
t-test		0.207873	0.410377	0.000484

	Does Technium help network with				
	Other Technium Companies	Tech Comp (SMEs)	Tech Comp (LEs)	Potential Investors	Other
1	1	1	1		1
2	1			1	
3	1	1	1	1	1
4	1			1	1
5	1			1	1
6	1	1	1	1	1
7					
8	1			1	1
9	1	1		1	
10	1				1
11	1		1		
12	1				
13	1	1	1	1	1
14	1	1	1	1	1
15	1				1
16	1	1	1	1	1
17	1	1	1		1
18	1	1	1		1
19	1	1	1	1	1
20	1	1	1	1	1
21	1	1			1
22	1	1			1
23	1				1
%	95.65	56.52	47.83	52.17	78.26

Networking

Control Group Companies

	Since Attracted			
	Gov. Grants	Angel Investment	Venture Capital	Comm Partners
1	1	1		
2	1			
3	1			
4	1			
5				
6	1			
7	1	1		
8	1			
9				
10				
11	1			
12				
13	1	1		
14	1	1		
15	1			1
16				1
17	1			
18	1			1
19				
20	1		1	
21				
22				
23				
24	1			
25				
	65.2173913	17.3913043	4.3478261	13.04348

Technium Companies

	Since Attracted			
	Gov. Grants	Angel Investment	Venture Capital	Comm Partners
1	1			
2				1
3	1	1		
4				
5	1			1
6				1
7				
8	1			
9	1	1		
10	1			
11	1		1	
12	1		1	
13	1			1
14	1			
15	1			
16		1		
17				
18				
19				
20				
21				
22				
23				
%	68.75	18.75	12.5	25

Source of Initial Support					
Gov. Grants	Founders own funds	Angel Investment	Parent Company	Other	Bank Loans
0	0	0	100	0	0
	50	0	0	0	50
25	25	25	0	0	25
	100				
40	60				
40			60		
	50			30	20
8	1			88	3
20	40				40
	100				
				100	
				100	
10	50				40
20	20	60			
	100				
			100		

Technium Support

	Established without Technium?						Technium effect to date					Envisaged Future Technium Effect				
	Sooner	Same time	Later	Not at all	In Wales	Else-where	Very Positive	Positive	Indifferent	Negative	Very Negative	V. Pos	Pos	Indiff	Neg	V. Neg
1				1		1		1					1			
2		1			1			1					1			
3			1			1		1					1			
4		1				1		1					1			
5		1				1		1					1			
6				1		1		1					1			
7																
8		1			1		1					1				
9		1					1						1			
10		1				1	1					1				
11		1			1		1						1			
12			1					1						1		
13		1				1		1					1			
14		1			1			1					1			
15		1			1			1					1			
16						1	1						1			
17			1			1		1					1			
18		1				1		1					1			
19				1				1					1			
20			1		1			1					1			
21		1			1		1						1			
22																
23		1				1		1					1			
%	0.00	56.52	17.39	13.04	30.43	47.83	26.09	65.22	0.00	0.00	0.00	8.70	78.26	4.35	0.00	0.00

Expected Support							Support Found							Added Value						
Bus Ops	Dev Collab (Ind)	Dev Collab (Aca)	Marketing Access to markets	Manage-ment	Access facilities	Attract Finance	Bus Ops	Dev Collab (Ind)	Dev Collab (Aca)	Marketing Access to markets	Manage-ment	Access facilities	Attract Finance	Business Operations	Develop Collaborations (Industrial)	Develop Collaborations (Academic)	Marketing Access to markets	Management	Access facilities	Attract Finance
1	1	1			1		1	1	1			1		1	1	1			1	
		1			1			1	1	1		1			1	1	1		1	
	1	1	1		1	1		1		1		1	1		1					1
			1		1															
1		1			1			1	1	1		1	1		1	1			1	1
		1			1		1		1	1		1	1	1		1	1		1	1
1	1	1			1		1	1	1			1	1	1	1				1	
					1		1					1	1	1					1	1
1			1		1		1			1		1		1			1		1	
1	1					1	1	1			1		1	1				1		1
		1					1						1		1					
1					1		1					1		1					1	
						1	1	1		1	1					1			1	
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1			1	1	1	1	1			1	1	1	1	1				
1							1	1	1	1	1	1	1	1	1	1	1	1	1	1
		1	1	1	1	1			1	1	1	1	1			1	1	1	1	1
		1	1	1	1	1			1	1	1	1	1			1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1			1		1	1	1			1			1	1			1	
47.83	34.78	56.52	30.43	17.39	69.57	34.78	60.87	52.17	52.17	47.83	30.43	69.57	56.52	47.83	47.83	52.17	34.78	26.09	65.22	43.48

Other Support

Control Group

	Public Sector Support							Private Sector Support						
	Start-up support	Finance advice	Finance (grants)	Legal Advice	HR Support	Marketing Support	Other	Start-up support	Finance advice	Finance (grants)	Legal Advice	HR Support	Marketing Support	Other
1	1	1	1	1	0	1	1		1	0	0	1	0	0
2	0	0	1	0	0	1	0	0	0	0	0	0	0	
3	1		1	1	1	1	1	1		1	1	1		
4			1	1		1	0	0	0	0	0	0	0	0
5														
6				1					1	1				
7			1			1			1	1	1			
8		1	1	1		1			1			1		
9														
10	1													
11				1										
12	1	1									1			
13	1	1	1	1	1	1				1				
14	1	1	1	1		1	1		1			1		1
15	1		1	1		1			1	1	1	1		
16	1					1	1				1			
17					1				1		1	1		
18			1	1		1		1	1	1	1	1		
19				1					1					
20		1	1	1	1	1							1	
21														
22	1													
23														
24		1												
25														
	36	28	44	48	16	48	16	8	36	24	28	28	4	4

Technium Companies

	Public Sector Support							Private Sector Support						
	Start-up support	Finance advice	Finance (grants)	Legal Advice	HR Support	Marketing Support	Other	Start-up support	Finance advice	Finance (grants)	Legal Advice	HR Support	Marketing Support	Other
1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2	1	0		1	0	1	0	0	1	0	0	0	0	0
3	1	1	1	1	0	1	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	1	1	0	1	1	0	0	0	1	1	0	1	0
6	0	1	1	1	1	0	1	0	0	0	0	0	0	0
7														
8	0	0	1	1	1	1	1	0	1	0	1	0	1	1
9	1	1	1			1	1				1			
10	0	1	1	1	1	1	0	0	1	0	1	1	0	1
11	0	0	1	1	0	1		0	0	0	0	0	0	0
12	0	0	1	0	1	1		1	1	1	1	1	1	1
13	1	1	1	0	1	0	1	0	0	1	0	0	0	0
14	1	0	1	1	1	0	0	0	0	0	0	0	0	0
15			1	1	1	1								
16	0	1	0	1	1	1	1	0	1	0	1	0	1	0
17														
18														
19														
20														
21														
22														
23														
	31.25	43.75	75	56.25	56.25	62.5	31.25	6.25	31.25	18.75	37.5	12.5	25	18.75

Appendix 12

Using Experts in the Identification of Challenges to the development of a Regional Knowledge Economy

Using experts in the identification of the challenges to the development of a Regional Knowledge Economy

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Abstract

This paper describes the process adopted in the use of an expert panel for the identification and understanding of the challenges facing the development of a Knowledge Economy Strategy for the Wales Spatial Plan region of Swansea Bay, Waterfront and Western Valleys.

The process involved working with a group of national and regional stakeholders using a variety of techniques including focus groups, Delphi groups and individual interviews to develop a consensus of the challenges facing the region. Recommendations were then developed in response to these challenges to form a Regional Knowledge Economy strategy.

1. Introduction

Wales, a small country of the United Kingdom is situated on the western periphery of the European Union. It has, particularly in the south west region, been undergoing massive economic change since the decline of its coal and steel industries. Inward investment by multinational firms helped provide employment opportunities during the 1980/90s though this is now suffering in face of competition from China, India and the recent enlargement of the European Union. Therefore, the Welsh Assembly Government (WAG) has moved focus onto development of indigenous enterprise in the Knowledge Economy, where value is in the knowledge upon which the enterprise is based, not the cost of labour or other raw materials. This is embodied in the broad strategy of WAG, Wales: A Better Country[1] and in the economic strategy, Wales: A Vibrant Economy[2]. Both of these describe how the Wales Spatial Plan (WSP)[3], a key programming document will deliver the requirement that:

> "We need an innovative, high value economy for Wales which utilises and develops the skills and knowledge of our people: an economy which both creates wealth and allows that prosperity to be spread throughout Wales: an economy which adds to the quality of people's lives as well as their living and working environments."
>
> Wales Spatial Plan p.16[3]

2. Our Wales Spatial Plan Region

The WSP outlines the collective vision for Wales and six distinct regions, each of which has its own geographical, economic and social challenges. Each of these regions is subsequently charged with developing themes that address these challenges and integrate with the aspirations and strategy of WAG. One of the themes under development in our region of Swansea Bay, Waterfront and Western Valleys is the Knowledge Economy. This is in reflection of the change for our region described in the WSP of:

"- Retaining young people and attract well-qualified people from outside the area to provide a stimulus for improved economic performance.
- The University, FE Colleges and Technia should embed the Knowledge Economy within the area."

Wales Spatial Plan p.55[3]

2.1 The Steering Group

The Spatial Planning process involves national and regional stakeholders from a broad range of organisations in order to reflect the various themes that are often cross-cutting and interrelated. The development of the Knowledge Economy theme is therefore carried out by a grouping of these stakeholders who form a Steering Group for the process. Membership of the Steering Group was predefined by the Spatial Planning Group. It included representation of a range of regional and national stakeholders, including the Local Authorities, the regional development agency (which was subsequently merged with WAG), other business support organisations, further education and higher education providers along with others such as the Environment Agency and the Countryside Council for Wales. The City and County of Swansea was appointed to co-ordinate development of the strategy, with the University of Wales Swansea acting to provide research and facilitation support.

One early observation of both the Steering Group and the research team was the absence of direct private sector representation. This was of particular note, as the theme being developed is clearly aimed at developing and supporting innovation in private enterprise in the region.

2.2 Strategy Development

The first stage of the strategy development focused on defining what the region needs to achieve and the challenges faced in achieving this. This was done to ensure solutions proposed in the recommendations phase addressed real challenges, not perceived or poorly defined ones. Presented in the following diagram and described below are the phases of the Strategy Development.

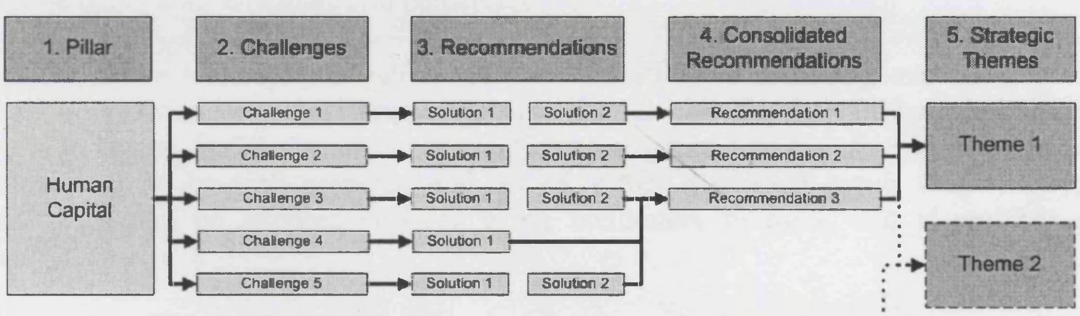

Fig. 1 High-Level Strategy Development Plan (excerpt)

1. Building on the Pillars – The 'Pillars' Model of the Knowledge Economy used by the World Bank[4] was adopted to provide a structure in which to develop the strategy. This integrated the ambitions of the European Union Lisbon strategy together with the ambitions of the UK government[5] and WAG[2] for the Knowledge Economy.

2. Identifying the Challenges – The challenges faced by the region were identified, using the process described in this paper. This process was supported by desk and other research to provide the expert group with the information they required.
3. Development of recommendations – Recommendations were provided by the stakeholders who were provided with information on ongoing efforts within the region, examples of successful practice from other regions.
4. Consolidation of Recommendations – The recommendations received from the Group were rationalised to remove duplication and capture the ideas of all stakeholders. This consolidated list was sent back to the stakeholders for validation.
5. Identification of Strategic Themes – Recommendations were gathered together under a set of Themes that emerged from interrelated recommendations. This list of identified themes was sent back to the stakeholders for review and validation.

3. Research using Groups

There are various ways in which to use groups of experts in conducting research of this nature including: Focus Groups, Delphi Groups and One to one interviews. Each of these methods has its own advantages and disadvantages and is only as useful as the quality of its application.

Focus Groups use the interaction of the individuals to enhance output through stimulation of each other's ideas(6). Focus groups offer the opportunity to and for views to be tested and challenged in real-time(7). However, a serious challenge in the use of focus groups can be dominant personalities that can affect the group dynamic and distort the input received(8).
Delphi Groups are another manner in which groups of experts can be used. Pioneered by the RAND Corporation(9), the method uses (normally four) rounds of structured communication with individuals with rounds of feedback that provide a degree of anonymity and has often been used in government planning exercises(10).
Individual Interviews are a further way of using experts in research. This also can avoid challenges of dominant personalities in groups and working with individuals has also been shown to improve productivity, particularly in brainstorming activities(11). However, this technique lacks the group dynamic where views can be developed through discussion between stakeholders. Interviews rely heavily upon the ability of the interviewer as well as the interviewee being both articulate and perceptive(12).

Each of the above techniques requires accurate and effective recording and interpretation of information provided. Another issue requiring careful consideration before and during the process is to ensure facilitation does not create bias at group sessions. To aid in achieving this facilitators need to be well prepared and record, rather than steer input. Additionally, other practical steps can be adopted such as using facilitators in pairs, and if possible gender balanced(13).

4. Identifying Challenges - Application

The methodology used in the identification of the challenges incorporated focus groups, Delphi groups and individual interviews at distinct phases, depending upon which was most appropriate.

Fig. 2 Challenge Identification Plan

Developing the Expert Group: It was clear that to properly identify the challenges the Steering Group would need to incorporate individuals with specialist knowledge and expertise (experts) in the wider scope of the Knowledge Economy. Industrialists, from businesses including hi-technology SMEs and multinational manufacturers, along with IP specialists, technology commercialisation experts and legal professionals joined the Steering Group to form a wider Expert Group. This ensured that the group was representative of all stakeholders involved in the theme and incorporated the range of expertise required to address the issues under consideration.

Phase 1: Defining a Starting Point – A common starting point and a common goal

The first phase of identifying the challenges was to develop a common understanding amongst the Knowledge Economy and what the Strategy Development aims to achieve, providing stimulus for Phase 2. This developed understanding of the Knowledge Economy amongst the stakeholders in the context of the strategies and vision of WAG.

Phase 2: Identifying the Challenges – 1st Expert Group Meeting

The Steering Group was broken down into a set of three Focus Groups: Human Capital (e.g. HE and FE reps), Infrastructure (e.g. local authority and business support reps.) and Innovation (hi-tech SMEs and tech. transfer reps.), with each group including both public and private sector representation to provide balance.

Phase 3: Understanding the Challenges – Stakeholder Interviews

These individual interviews were conducted in anonymity from other Group members with combined results fed back to the experts as a Delphi Group so as to allow greatest possible freedom of expression and so that individuals (even of the same organisation) were unaware as to with whom they may or may not be agreeing. Two interviewers met with each stakeholder in order to ensure comprehensive records were kept and to provide consistency between interviews.

Phase 4: Prioritising the Challenges – Prioritisation Survey

The challenges identified and described through Delphi feedback rounds were passed anonymously to the members of the group for ranking. The results of this exercise were presented to the whole expert group at a focus group meeting where the differences were discussed amongst three sub-groups mixing public, private and education sectors. Moderators recorded these discussions to aid in the development of the Interim report.

Phase 5: Agreeing on the Problem – Interim Report

The Interim report was the final output of the Challenge Identification Phase, providing a formal consensus for subsequent phases of the strategy development. This report collected the output of the phases described above together with the stimulus materials and information provided to the group. This made use of the stakeholders as a Delphi Group to allow free input while stimulating each member with the anonymous input of their peers. Feedback received from the group was then incorporated into the report over two cycles before being finalised.

5. Conclusions

The methodology described above was successfully implemented in developing consensus of the challenges facing development of the regional Knowledge Economy. Group sessions allowed stimulation of ideas amongst individuals, where they could to articulate their own views and receive those of other stakeholders, while individual interviews provided the opportunity for members to discuss issues they may (for whatever reason) not have had either inclination to opportunity to during the . Incorporating this into material circulate to the Expert Group in Delphi method exercises ensured that all ideas were fed back to the entire group for discussion/validation.

Providing anonymity for group members in individual interviews and Delphi method exercises (from both the rest of the Group and also their own organisation and peers) allowed experts to move from behind corporate positions that they my need to and provide more considered balanced information. Validation of these views by the wider group was then made through feedback of this information in Delphi method exercises which was then presented at Group meetings.

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Appendix 13

Expert Group Membership
Swansea Bay – Waterfront and Western Valleys: Knowledge Economy Strategy Development

Jim Abbey	Swansea University – Research Team
Nick Bennett	Gorseinon College
Eric Bowles	Brecon Beacons Nat Park
Gavin Bunting	Swansea University – Research Team
Betsan Caldwell	DEIN
Roger Carter	HEFCW
Brian Clarke	Trinity College
Marc Clement	Swansea University
Spencer Conlon	DELLS
Mark Dacey	Neath Port Talbot College
Gareth Davies	Swansea University – Research Team
Marion Davies	WAG
Roger Dinham	JCP
John Dyer	Carmarthenshire CC
Allan Gray	DEIN
Carol Green	SCVS
Richard Harris	DEIN
Phil Holmes	CCS
Martin Hooker	Bridgend CBC
Louisa Huxtable	Swansea University – Research Team
Clare James	CCS
Rhian Jardine	CCW
Mark Jones	Bridgend College
Pat Jones	DEIN, KEF
Nigel Keane	WSPU
Steve Marshall	Business Centre, CCS
Becki McKinlay	Swansea Students Union
David Morgan	DELLS
Peter Rees	Coleg Sir Gar
Phil Roberts	CCS
Maxine Room	Swansea College
Richard Rossington	WAG
Bethan Thomas	NUS
Wayne Thomas	NUM South Wales
Brian Thorne	DEIN
Russell Ward	NPT CBC Education
David Warner	SIHE
Will Watson	NPT CBC
Ruth Williams	National Trust
Mary Youell	Environment Agency

In addition to the Steering Group the membership of the Expert Group also includes:

Andrew Beale	IP Wales
Simon Bowen	Environmental Fuels Ltd.
Andy Button	HSBC
Ken Evans	HSBC
Bruce Heppenstall	GE
Peter Jones	Morgan Cole
Rod Thomas	IET
Chris Young	Welsh Electronics Forum

Appendix 14

Expert Group Meeting Presentation

Wales Spatial Plan

Swansea Bay – Waterfront and Western Valleys

Knowledge Economy Theme Strategy

Expert Group Meeting – 4th April 2006

Aims of This Session

- Progress an integrated Knowledge Economy Strategy for the Wales Spatial Plan region of Swansea Bay – Waterfront and Western Valleys
- Engage with Experts and Leaders from Private, Public and Governmental Sectors
- Identify the challenges facing the development of the Knowledge economy specifically in terms of;
  - Innovation
  - Infrastructure
  - Human Capital

Setting the context: Wales Spatial Plan

"A Strategic Framework to guide future development and policy"

Promoting a Sustainable Economy

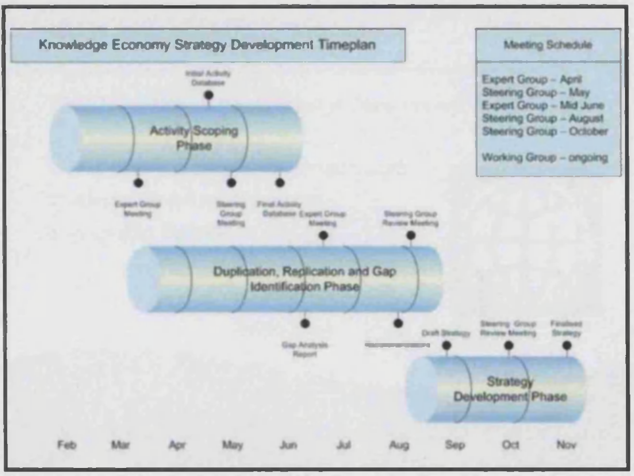
"We need an innovative, high value economy for Wales which utilises and develops the skills and knowledge of our people: an economy which both creates wealth and allows that prosperity to be spread throughout Wales: an economy which adds to the quality of people's lives as well as their living and working environments"

Setting the context: Wales Spatial Plan

Swansea Bay: Waterfront & Western Valleys is identified as one of six spatial areas

Knowledge Economy has been chosen as one of the key priorities for the spatial area

- City & County of Swansea is lead organisation
- Supported by a wider steering group of partners
- Swansea University providing the research expertise



The Lisbon Objective

The Strategic Objective set by the heads of government of the European Union at Lisbon in March 2000 is to become:

- the most competitive and dynamic knowledge-based economy in the world
- capable of sustainable economic growth
- with more and better jobs and greater social cohesion

"… The European economic base is changing, with ever more emphasis on the production and dissemination of knowledge…"

Commissioner Janez Potocnik

Objective 1: 2007 - 2013

First Minister Rhodri Morgan: December 2005

"…*The funding for West Wales and the valleys is likely to be around the current level – approximately £1.3bn over seven years – but the overall budget to the UK as a whole in terms of Regional Competitiveness is much smaller…*"

The Knowledge Economy

"…one in which the generation and exploitation of knowledge has come to play the predominant part in the creation of wealth."

Lord Sainsbury: Our Competitive Future:
Building the Knowledge Driven Economy, Dti, 2004

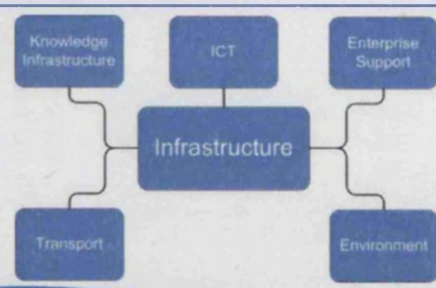
The Knowledge Economy

Three Key Pillars of the Knowledge Economy are:

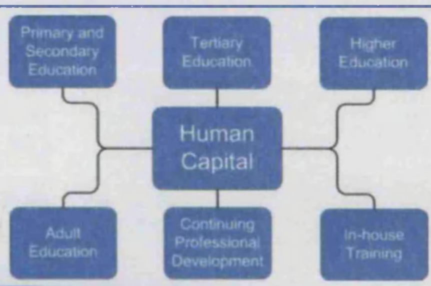
1. Economic and Information Infrastructure
2. Human Capital and Education
3. Innovation System

J.F.Rischard
World Bank

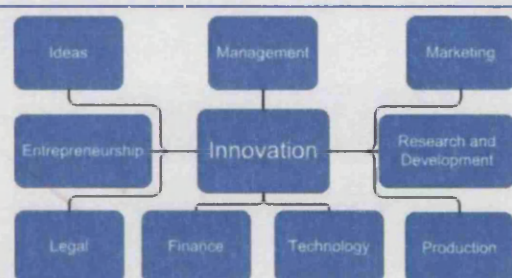
Infrastructure Themes



Human Capital Themes



Innovation Themes



Aims of This Session

- Break into three groups – 2:25 – 3:10pm
  - Facilitator nominated to each group
  - 1st 15 minutes: Address 3 questions on Infrastructure
  - 2nd 15 minutes: Address 3 questions on Human Capital
  - 3rd 15 minutes: Address 3 questions on Innovation
- The facilitator(s) will record key points of the discussion during the coffee break 3:10-3:30pm
- Combined discussion on outcomes -3:30-4:10pm
- Recap, Review and Action – 4:10-4:30pm

Group Session: Infrastructure

Knowledge Infrastructure

ICT

Transport

Enterprise Support

Basic and General Skills

Specific and Specialist Skills

Environment

What are the challenges in delivering a physical infrastructure (e.g. ICT, Transport) for Knowledge Economy in our Wales Spatial Plan Region?

What are the challenges in delivering soft infrastructure? (e.g. Entrepreneur Support & Knowledge Infrastructure)

What are the challenges in delivering skills/education infrastructure for Knowledge Economy in our Wales Spatial Plan Region?

Group Session: Human Capital

Primary/ Seconadry Education

Tertiary Education

HE

Adult Education

In-House Training

CPD

Basic & General Skills

Specialist & Specific Skills

What are the challenges in gearing the education system to provide suitable skills for the Knowledge Economy in our Wales Spatial Plan Region?

Identify challenges in using in-house training and CPD to develop Knowledge Economy relevant skills and drive innovation.

How in our education system can we lever greater advantage in provision of basic skills (e.g. low level ICT) and specific skills (e.g. sciences and engineering) required for the Knowledge Economy?

Group Session: Innovation

Ideas

Management

Marketing

Production

Legal

Entrepreneur

R&D

Technology

Fiance

What are the challenges to the stimulating ideas, idea creation and R&D in our Wales Spatial Plan Region?

What are the specific challenges to creating high skilled management, marketing and production in in our Wales Spatial Plan Region?

What are the challenges in creating an environment conducive to entrepreneurship and innovation?

Appendix 15

Expert Group Interviews – Aide Memoire

Human Capital

The development and use of knowledge and skills in the population is vital in the creation of a vibrant and growing Knowledge Economy. These skills relate not only to disciplines such as engineering, sciences and medicine, but also marketing, finance, law etc. These are all required to generate, attract and develop clusters of knowledge based industry.
How could the skills provision for the Knowledge Economy be tackled in the region?
How? By Whom?
What key Knowledge Economy skills are lacking within the region?
Do you think business in the region recognises the value of these skills?
How should the challenge of developing skills and experience through a career be supported?
Do you feel the education sector in the region engages with the needs, particularly those of the private sector? How could this be improved?
How can engagement between education and private sector to provide appropriate skills be facilitated?
What skills initiatives and support do you feel are working well?
What support/incentive could lead people to acquiring suitable skills?
What other issues/comments do you have on the development of human capital for the Knowledge Economy in the region

Innovation

The development and exploitation of new ideas through innovative goods and services has been identified as the source of most potential future economic growth. The innovation process poses significant challenges to turn ideas into success, particularly in the needs for collaboration and forward-thinking.

What skills, services and resources required for innovation are lacking in the region?

Do you think business in the region appreciates the benefits of innovation?

How can greater support be given, particularly at;

- Entrepreneurship
- Developing Ideas
- Identifying and exploiting markets
- Raising Finance
- Proof of Concept
- Other

How can innovative collaboration between organisations, particularly companies be encouraged?

How can a culture of innovation be fostered and which organisations should take the lead?

What innovation support initiatives are working well in the region?

What other issues/comments do you have on the development of innovation in the Knowledge Economy in the region

Infrastructure

Business support, ICT and transport links are all examples of infrastructure underpinning the Knowledge Economy. These are all needed to support innovation systems and facilitate the movement of ideas, finance and human capital
Which parts of the Knowledge Economy infrastructure could be integrated to provide better support?
What gaps exist in the support infrastructure for the Knowledge Economy?
How could this integration and focusing of efforts be achieved?
How can the private sector become more involved in its role in the infrastructure?
How and where can ICT tools be levered to greater effect in the Knowledge Economy activities?
What types of support are working well in the region?
What other issues/comments do you have on the development of infrastructure for the Knowledge Economy in the region

Technium

Technium has been identified by the Expert Group as a delivery mechanism for various parts of the Knowledge Economy in the Spatial Plan region. It represents an integrated piece of infrastructure, providing opportunities to develop human capital and innovation.

How does/should/could Technium interact with your organisation?

Does –

Should –

Could –

Do you feel Technium has a positive benefit on the Knowledge Economy? Please discuss

How could Technium help identify and nurture early stage opportunities?

How could Technium have greater impact in developing the Knowledge Economy, in terms of human capital, innovation and infrastructure?

What other issues/comments do you have on the development of Technium for the benefit of the Knowledge Economy in the region

Appendix 16

Expert Group Challenge Prioritisation Survey

Wales Spatial Plan

Swansea Bay - Waterfront and Western Valleys

Knowledge Economy Theme

Expert Group Meeting – Identified Challenges

The following tables present the range of challenges identified at the Expert Group Meeting. We would be grateful if you could please review these lists and prioritise the challenges in ranging from those that have the most impact upon the development of the Knowledge economy to those which have the least, before returning them electronically.

Thanks,

The Research Team

1. Infrastructure	
	Rating
Need for effective partnerships and collaboration to develop infrastructure effectively communicating at all levels	Select Priority
Support Technium and a wider incubation chain to develop earlier stage business	Select Priority
ICT Consolidation and innovation required to harness true potential of technologies	Select Priority
Need for Technium to reach into FE and schools	Select Priority
Requirement for effective Joined up – can do – client management system	Select Priority
Lack of focus, awareness and integration of support available	Select Priority
Integration of soft and physical infrastructure (e.g. integrating business support and Technium centres)	Select Priority
Need to understand roles of all types of transport and dependence of knowledge economy upon this	Select Priority
Embrace Private Sector in providing and utilising infrastructure (e.g. support services, ICT etc.)	Select Priority

2. Human Capital	
	Rating
Provide skills supply to match market requirement	Select Priority
Need to engage with and embrace schools, FE and parents to develop culture and aspirations	Select Priority
Need for collaboration within and across sectors and institutions – starting with effective communication	Select Priority
Constraints of National Curriculum in fostering creativity, innovation and entrepreneurship	Select Priority
Need to provide opportunity for knowledge economy skills to be utilised and developed	Select Priority
Need for the practical application of theory to be properly addressed in education	Select Priority
Facilitate exchange of teachers and pupils to broaden horizons	Select Priority
Review relevance, effectiveness and efficiency of education and training provision	Select Priority
Highlight fact that Knowledge Economy is not elitist/techie	Select Priority
Encourage all to understand and participate in opportunities	Select Priority
Acknowledge that life skills are of key importance in the knowledge economy	Select Priority

3. Innovation	
	Rating
Lack of business skills	Select Priority
A risk averse and lack of risk management is stifling innovation	Select Priority
The current business support infrastructure not working as well as required to support innovation	Select Priority
Bureaucracy associated with public support creates a hindrance to business	Select Priority
Difficulties in attracting venture capital to regions to support often costly innovative activity	Select Priority
'Ticks in boxes' culture of inappropriate targets concentrating on new opportunities, resulting in neglect of existing companies	Select Priority
Celebrate success while acknowledging, learning and moving on from failure	Select Priority
Spend money in community by promoting local services, skills and facilities	Select Priority
Need to raise the profile of the region and its activities beyond its borders	Select Priority

Appendix 17

Swansea Bay – Waterfront and Western Valleys: Knowledge Economy Strategy Development
Identified Challenges

8.1 Human Capital Challenges

The first Expert Group meeting also identified a number of Human Capital challenges in the Knowledge Economy. These were generally high-level issues that are faced by all regions. These challenges were refined during the research and stakeholder interview phase. Presented below is a list of these challenges together with an overview of the general consensus found through the individual stakeholder interviews. The list below applies no particular order.

- Develop a skills supply to fulfil the needs of a regional Knowledge Economy
- Developing a culture of innovation and aspirations for entrepreneurship through partnerships including schools and FE colleges
- Facilitating collaboration across sectors and institutions – starting with effective communication
- Addressing the constraints of the National Curriculum to nurture creativity, innovation and entrepreneurship
- Provide opportunities for Knowledge Economy skills to be utilised and developed
- Develop the link between theory learnt in education and its practical application
- Facilitate exchange of pupils and teachers to broaden horizons
- Review relevance, effectiveness and efficiency of education and training provision
- Providing the understanding that the Knowledge Economy is not elitist / techie as numerous roles and opportunities exist

Challenge: Develop a skills supply to fulfil the needs of a regional Knowledge Economy
Matching the skills supply to the demands of the Knowledge Economy is a challenge for any region. The education providers in the region face the dual challenges of creating demand amongst individuals for such skills while having to work within funding frameworks that are still developing a response to these needs of the economy. The education system works as a 'buyers market', though the buyers need to be better informed as to the implication of their choices and the 'production quotas' approach for certain courses needs revision. Furthermore, a regional lack of certain skills, not only those relating to science and technology, but also will require far greater attention in the future. (See also Innovation challenges).

Challenge: Developing a culture of innovation and aspirations for entrepreneurship through partnerships including schools and FE colleges
Much has been achieved in recent years of creating a more innovative and entrepreneurial environment and culture within education. However, it is recognised that the facilities and support developed to date will require a strengthening of the aspirations of individuals to embrace such opportunities. This challenge is regarded as most acute in areas of the region where employment aspirations and educational achievement are particularly low. However, it is recognised that development will likely occur at different rates and to different levels over any given period of time, while the ultimate goal of equal opportunity and success is pursued.

Challenge: Facilitating collaboration across sectors and institutions – starting with effective communication
Addressing the challenge of creating effective collaboration in the region's education sector is crucial to delivering a coherent strategy for skills supply. The absurdity of institutions effectively 'competing' for the same students to do the same course must be avoided and will require the collaboration of education institutions and those that fund them.

Challenge: Addressing the constraints of the National Curriculum to nurture creativity, innovation and entrepreneurship
Fulfilling the requirements of the National Curriculum has been highlighted as a constraint in devoting time and resource to the development of creativity, innovation and entrepreneurship amongst pupils and students. The challenge remains to integrate these objectives with the delivery of the curriculum to achieve all of these requirements. This may involve innovative approaches to curriculum delivery and development of extra-curriculum activities.

Challenge: Provide opportunities for Knowledge Economy skills to be utilised and developed

The provision of opportunities in the region that require, exploit and further develop Knowledge Economy skills is key to catalysing development of the Knowledge Economy, encouraging investment and demonstrating Knowledge Economy career paths to the regional labour pool.

While a transition from the regional dominance of traditional industries to more knowledge intensive ones is underway this evolution of the regional economy needs to be supported, both through nurturing of new enterprise and encouraging inward investment.

Challenge: Develop the link between theory learnt in education and its practical application

Linked to challenges related to curricula and providing opportunity, the use of knowledge is central to the Knowledge Economy and this needs to be reflected in education to best prepare individuals for their futures.

Challenge: Facilitate exchange of pupils and teachers to broaden horizons

Key to creating an innovative culture and entrepreneurial aspirations amongst pupils and students is the development of an understanding and appreciation of these concepts in their teachers and lecturers.

In order to achieve this, the challenge is faced of extending the interaction of business and education at an individual as well as institutional level. This links closely with the challenge of linking theory presented in education with its practical application. An obvious example of where this is already tried is through school work placements.

Challenge: Review relevance, effectiveness and efficiency of education and training provision

As the economy evolves its skills needs also change. This needs to be considered in order to ensure that future provision will help the growth of the Knowledge Economy. This poses the challenge not only of delivering appropriate education and training but also identifying what the education and training should be.

In addition, the development of ICT has created a range of opportunities to exploit new delivery methods, which as well as increasing access can also act to develop evermore important ICT skills.

Challenge: Creating an awareness that the Knowledge Economy is not elitist / 'techie' as numerous roles and opportunities exist

The challenge was identified of highlighting that the Knowledge Economy is not the preserve of those with scientific/technical skills or to a small group of technology entrepreneurs.

This requires presenting an understanding of the roles and opportunities that exist (and will exist in the future) and the paths available to their attainment.

8.2 Innovation Challenges

The first Expert Group meeting also identified a number of Innovation challenges in the Knowledge Economy. These were generally high-level issues that are faced by all regions. These challenges were refined during the research and stakeholder interview phase. Presented below is a list of these challenges together with an overview of the general consensus found through the individual stakeholder interviews. The list below applies no particular order.

- Addressing a lack of key business skills in the region
- Confronting a risk averse culture with a lack of risk management skills that is stifling innovation
- Facilitating the evolution and strengthening of current business support to address the new challenges of the Knowledge Economy
- The bureaucracy associated with much public support that hinders its uptake by business
- Attracting further venture capital and other enterprise investment to new and existing opportunities the region
- Acknowledging and nurturing the wider set of skills required to perform in the Knowledge Economy
- A 'ticks in boxes' culture of inappropriate targets concentrating on new opportunities, resulting in neglect of existing companies
- Celebrate our successes while leaning and moving on from failure
- Retain and develop opportunity in the region by promoting local services, skills and facilities
- Raise the profile of the region and its activities beyond its borders

Challenge: Addressing a lack of key business skills in the region
Developing knowledge businesses requires business skills. The lack of such skills in the region is regarded by all sectors as being a major obstacle to the development of clusters of the regional Knowledge Economy. Without the appropriate skills required to establish and grow new and existing the companies, the benefits of ideas and opportunities created within the region will move elsewhere or be completely lost. The challenge consists of nurturing home-grown talent within the region and attracting back experience and the associated personal networks. This reflects the global nature of the Knowledge Economy where real value is generated by working with, rather than against or in isolation from, the rest of the world.

Challenge: Confronting a risk averse culture and a lack of risk management skills that is stifling innovation
In a region hit hard by economic change and where employment has often been in a 'job for life', the transition to a more entrepreneurial culture is difficult. This challenge requires provision of better information about and support to embark upon entrepreneurial activity. The risks associated with venturing into the Knowledge Economy must be identified, acknowledged and managed. Simply ignoring them, or worse still, regarding them as avoidable, are not options for the future. The result of either approach would be to do nothing (and sink) or face unknown risk. This challenge ties in closely with that regarding the lack of business skills. Success will not come from ignoring risk or deciding against progress because a risk exists, but rather from its effective management.

Challenge: Facilitating the evolution and strengthening of current business support to address the new challenges of the Knowledge Economy
As the economy evolves, business support needs to evolve alongside. This co-evolution has already been seen as the approach of stakeholders, particularly those in economic development, has changed over recent years. Much success has been achieved in creating new knowledge businesses and the challenge is now to sustain this creation and facilitate the growth of the new businesses already created.

Challenge: The bureaucracy associated with much public support that hinders its uptake by business
Public sector support is carefully monitored to ensure resources are appropriately used though the bureaucratic overheads of many programmes were regarded as a major hindrance to delivery and accessibility by both users and providers of support. Therefore the challenge exists to streamline this bureaucracy to ensure value for public money, not only through providing effective monitoring, but also in ensuring resources are not diverted from the key mission of providing support to monitoring efforts.

Challenge: Attracting further venture capital and other enterprise investment to new and existing opportunities the region
Attracting investment into enterprise in a relatively peripheral region of the UK and Europe was regarded by many as being a key challenge in developing knowledge businesses that can continue to grow in the region. However, it was felt by some stakeholders (including some leading knowledge businesses) that investment will come if the opportunity is there. This would transform the challenge into one of highlighting the potential in individual opportunities and the region as a whole.

Challenge: Acknowledging and nurturing the wider set of skills required to perform in the Knowledge Economy
It was acknowledged that the Knowledge Economy is particularly reliant on a broad set of skills, many as basic as team working and communication. While development of these falls to some extent within traditional disciplines it is essential for the Knowledge Economy. Furthermore, the traditional industries that make up much of the employment within the region and the low level of participation in education means development of these skills in individuals can often be quite limited.

Challenge: A 'ticks in boxes' culture of inappropriate targets concentrating on new opportunities, resulting in neglect of existing companies
Associated with the challenge of bureaucracy in public sector support, it was felt by many stakeholders that certain monitoring criteria concentrated too much upon formation of new enterprise and not enough upon development of existing ones.

Challenge: Celebrate our successes while learning and moving on from failure
The concept of failure, particularly in parts of the public sector, which are heavily monitored and/or politicised, is difficult to comprehend. However, enterprise is central to the Knowledge Economy and alongside the successes (of varying size) there will undoubtedly be some failure. Key will be championing the many successes and learning from them, just as from the failures, to move forward.

Challenge: Retain and develop opportunity in the region by promoting local services, skills and facilities
Many roles and services for knowledge businesses are sourced from outside our region. This means much of the value of the economy is lost beyond the region and reduces scope for the growth of knowledge based enterprise. The challenge is to champion and strengthen existing provision and create new provision within the region. This will serve to strengthen the Knowledge Economy within the region, attracting and supporting new and inward investing business, while creating new opportunities for individuals and enterprise.

Challenge: Raise the profile of the region and its activities beyond its borders
Linked to the challenge of celebrating success, the region needs to raise its profile to capitalise on what it has achieved and its future potential. The region is well placed in the global Knowledge Economy, sitting close to Wales' capital city and not far from the world-leading major European city of London.

8.3 Infrastructure Challenges

The first Expert Group meeting identified a number of Infrastructure challenges in the Knowledge Economy. These were generally high-level issues that were refined during the research and stakeholder interview phase. Presented below is a list of these challenges together with an overview of the general consensus found through the individual stakeholder interviews. The list below applies no particular order.

- Creation of effective partnerships and collaboration to develop infrastructure, with effective communication at all levels
- Support the Technium initiative and the wider incubation chain, to in particular develop earlier stage opportunities
- Innovation in and the consolidation of Internet and Communication Technologies (ICT) to harness their potential in the Knowledge Economy
- Opportunity to use success of Technium to develop culture in schools and Further Education
- Develop awareness of the support infrastructure available and facilitate integration of efforts and refocusing as appropriate
- Development of a client-focused support infrastructure to face the new business development challenges of the Knowledge Economy
- Integration of the soft and physical business support infrastructure
- The need to understand the role of transport links in the region and how this impacts upon the Knowledge Economy development
- Facilitate the interaction and co-existence of public and private business support services

Challenge: Creation of effective partnerships and collaboration to develop infrastructure, with effective communication at all levels
Effective partnerships are regarded by all as being critical in delivering a Knowledge Economy infrastructure for our Spatial Plan region. As the Knowledge Economy lends much scope for developing individual niches (rather than direct competition), collaborations can create opportunities and roles for a multitude of organisations in delivering key goals. The need in such partnerships for communication, at and between, strategic, managerial and operational levels was described by stakeholders from all sectors. Creating such partnerships requires an understanding of the challenges faced by other partners and the acceptance of some compromise to achieve the greater returns.

Challenge: Support the Technium initiative and the wider incubation chain, to in particular develop earlier stage opportunities
The Technium initiative and other business development infrastructure in the region such as Ideapolis at Neath Port Talbot College was singled out by the Expert Group as playing a pivotal role in the creation and development of knowledge businesses in the region. However, the importance of supporting such efforts as economic development rather than property initiatives was voiced strongly by parties across all sectors, as failing to do so risks the future of a pipeline of incubating knowledge businesses. Furthermore, the need to nurture enterprise earlier in its development was described. It was felt that the future challenge for the business development infrastructure would be supporting the steps between idea/company formation and initial growth phases. This links with the challenge of integrating the incubation and business development activities in the region.

Challenge: Innovation in and the consolidation of Internet and Communication Technologies (ICT) to harness their potential in the Knowledge Economy
While great advance has been made in improving access to ICT the next stage of the challenge is regarded as being harnessing its potential for facilitating and developing related business opportunities and its wider use in delivery of business support. This challenge relates closely to the Human Capital challenge where ICT skills are now becoming regarded as part of 'basic' skills.

Challenge: Opportunity to use success of Technium to develop culture in schools and Further Education
Technium was regarded by many in the education sector as being a powerful regional beacon for innovation and knowledge-based enterprise. Many organisations believed it could play an expanded role in developing a more entrepreneurial culture amongst students by demonstrating entrepreneurship and application of technology as potential career paths. However, it was found that despite a positive appreciation of the Technium initiative, many stakeholders from the education sector did not have a deep understanding or any level of involvement. Nevertheless all involved expressed the strong desire to engage in the future.

Challenge: Develop awareness of the support infrastructure available and facilitate integration of efforts and refocusing as appropriate
The multifaceted challenges of the evolving Knowledge Economy, and the ever-changing nature of technology has meant that many initiatives and support programmes have been developed over recent years to assist with business start-ups, technology development financing, etc. However, the sheer number of support providers and the range of assistance available has been identified as posing a challenge to businesses by stakeholders from all sectors. This poses the challenge of integrating efforts where possible and raising awareness of these consolidated offerings.

Challenge: Development of a client-focused support infrastructure to face the new business development challenges of the Knowledge Economy
Related to the two challenges described above, the need for an evolution in support infrastructure to help support businesses was much described. The challenge of delivering bespoke, rather than generic, support focused on an individual businesses need has become a recurrent theme. Furthermore, the nature of such support would require a clear point of contact (i.e. a named individual) being responsible for the support delivery. Management of the relationship and delivery would remain their responsibility whether the support is given directly by them, or partly or completely by another party, as is common practice in the private sector.

Challenge: Integration of the soft and physical business support infrastructure
The opportunity to provide clear co-location of 'soft' (human) and 'physical' (facilities and resources) to provide a focus for support delivery was seen as a challenge that could help raise awareness and access for businesses. Often quoted examples of where this has been successful are the co-location of the ITCs and other support at Technium Swansea and the locating of KEF support at ECM2 and in Universities.

Challenge: The need to understand the role of transport links in the region and how this impacts upon the Knowledge Economy development
The challenge of the region engaging with the global nature of the Knowledge Economy was stressed by stakeholders of all sectors. The geography and topography of the region make this challenge more acute than for other regions. The importance of facilitating the movement of human capital, ideas, finance etc. within, into, and beyond the borders of our region is critical in the development of the Knowledge Economy. This will pose the challenge of integrating the development of the Knowledge Economy with the development of a sustainable integrated transport system, which reflects the needs of businesses and workers and engages beyond its borders.

Challenge: Facilitate the interaction and co-existence of public and private business support services
The role of the private sector support and services in the development of knowledge businesses, particularly those in growth and mature phases, was highlighted by both the public and private sectors. This poses the challenge of interfacing between public sector support and private sector service to ensure quality, integration and coverage of the entire range of support and services required by knowledge-based businesses.

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