

A communities of practice approach to promoting regional circular economy innovation: Evidence from East Wales

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Abstract:

With sustainability orientation and opportunities provided to economic growth, the circular economy is much promoted by the Welsh government in recent years. In this region, Communities of practice (CoP) are cultivated to link various industry sectors together, sharing knowledge and creating practical solution to circular economy related challenges. While current literature provides the framework of regional innovation ecosystem in the form of Triple Helix, the role of CoP is underexplored. The key research question of this paper is “how can CoP approach cultivate regional circular economy innovation?” Through an in-depth case study of the Communities of Circular Economy Innovation (CEIC) project in East Wales, the paper identifies the construct of CoP, dynamic lifecycle, and interaction between CoP and Triple Helix. Findings reveal that whilst university and government play leading role in innovation at early stages by deliberately establishing the CoP, the self-governance of CoP at later stages results in active influence on industry changes and policy designs. The paper contributes to the literature of micro-relations among regional innovation actors by highlighting the role of CoP in creating emerging new knowledge and tools. It also provides practical implications to industry and policy makers to promote regional circular economy.

Keywords: *Innovation ecosystem, Communities of practice, Triple Helix, Circular economy, Open Innovation*

1. Introduction

With sustainability orientation and opportunities provided to economic growth, the circular economy is much promoted by the Welsh Government in recent years, which has planned to be world-leading in reducing, reusing, and repairing (Constructing Excellence in Wales, 2022). In 2021, the government document *Beyond Recycling* clearly states the ambition to “*accelerate our transition to a circular, low carbon economy*” (Welsh Government, 2021, p.4). Sustainability-oriented innovation generally requires for collaboration, new process and business models (Liu and Stephens, 2019; Liu et al., 2019), whereas circular economy concerns broader issues in response to socio-environmental challenges (Ghisellini, Cialani and Ulgiati, 2016). The concept is premised on a development strategy and business model innovation that enables economic growth while optimising consumption and resources (MacArthur, 2013). It is a restorative and regenerative process by design, aiming to keep products, components and materials at their highest utility and value, which is hugely different to the conventional linear – take, make, waste - economy (MacArthur, 2013).

Defined as “*a circular economy aims to redefine growth, focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources, and designing waste out of the system. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital*” (Ellen MacArthur Foundation, 2022), circular economy is built upon three principles: 1) Design out waste and pollution, 2) Keep products and materials in use, and 3) Regenerate natural system. (Ellen MacArthur Foundation, 2022). As an emerging new concept, circular economy innovation is implemented at different levels. At an organisational level, resource coordination, product and process redesign, industry symbiosis can help companies to rethink about their business model and value chain, achieving more efficiency and effectiveness (White, Wang and Li, 2015; White, Sarpong and Ndrecaj, 2015; White and James, 2014; MacArthur, 2013; Chan, Wang, White and Yip, 2013). At national level, new sustainable approaches considering the balance of environmental and innovation ecosystems (White, Lomax and Parry, 2014; Moore, 1993; Adner, 2017) is an essential reference for the designing of industrial system (Shi et al., 2021). However, literature on the topic of circular economy mostly focuses on understanding the barriers to individual businesses, instead of identifying macro scale systemic barriers (Geissdoerfer et al., 2017).

In general, to promote regional innovation such as nurturing new processes, government plays a central role (Lee, Noh, and Seul, 2017; Ma et al., 2019; Liu, 2021). In Wales and UK, there is evidence of government imposing industry changes through formal planning, regulation, controlling and standardisation of the circular economy. Meanwhile, government enables knowledge sharing, job creation, and reducing environmental impacts at a regional level. Innovation in terms of technology, business model and social innovation can be the main drivers of the circular economy (Constructing Excellence in Wales, 2022). University-based green innovation related research projects emerge along with an increasing awareness of ethical and sustainable consumption from society. Industries - especially leading large firms - show increasing commitment in R&D, exploring green technology for commercial use. The collaborations between university and industry are conducted through joint research, and knowledge transfer based on patents and knowledge developed by university and research labs (James et al., 2022; White, et al., 2020; White, et al., 2018). These factors together promote a network-featured regional innovation ecosystem known as the Triple Helix (Razak et al., 2016; Razak and White, 2015; Etzkowitz, 2003).

Whilst most innovations, including open innovation (Chesbrough, 2003) and its broader context of innovation ecosystem (Moore, 1993; Adner, 2017), happen based on the fact knowledge are known, the promotion of circular economy heavily relies on the awareness of industry and practitioners. The concept of communities of practice (CoP) can potentially link various industry sectors together, generating knowledge and practical solutions. CoP are rooted in the domain of shared experience and expertise and can be an essential component of the move to a circular economy (Robins, 2019). As a relatively loose structure often self-organised, CoP represents professional informal collaboration and communication networks (Ji, Sui and Suo, 2017), sometimes emerging unplanned to support incremental innovation in the form of problem-solving activities (Pattinson and Preece, 2014.). CoP can also promote the awareness of sustainability through the network effect (Walpole et al., 2022). Rather than a specific tool, circular economy is more of an evolving concept to be identified and adjusted to industry contexts. Hence, apart from traditional formal partnership between university and industry, or alliance and cluster around a single industry sector, CoP can bring in various resource across sectors at regional level.

There have been empirical studies of the Triple Helix and innovation ecosystem in terms of the nurturing new business sectors. However, the exact construct of regional innovation ecosystem, the evolving process, and interaction mechanism in the context of capturing an emerging new concept, business model, or solution rather than a specific industry – in this case, the circular economy – is underexplored. CoP is an important source of innovation, especially when innovation refers to novel solution in an application environment (Muller and Ibert, 2015). Nevertheless its position in the regional innovation system represented by the Triple Helix framework is not clear. Important aspects need in-depth investigation, including the structure and evolution paths of CoP around circular economy, alongside its connection with other regional innovation actors, namely university, industry, government at various stages.

Based on the above background, our research question is “how can CoP approach cultivate regional circular economy innovation?”. Specifically, there are three objectives: 1) to identify the construct of CoP which drives regional innovation ecosystem; 2) to explore the dynamic evolution process of CoP alongside circular economy innovation; and 3) to examine the interactive mechanism between CoP and other regional innovation ecosystem actors, e.g. university, industry, government.

To answer the research question, the paper conducts an in-depth case study a circular economy-oriented CoP in the East Wales region of UK. The remainder of the paper is structured as follows. After this section, Section 2 reviews current literature on regional innovation ecosystem and CoP. Section 3 describes the research methodology. This is followed by the overview of the case study in Section 4. Section 5 elaborates research findings and generate three important propositions. Conclusion including theoretical and practical implication of the research is addressed in Section 6.

2. Literature Review

2.1. Open Innovation and Regional Innovation Ecosystem

Since it was introduced in 2003, open innovation is adopted to increase embrace of external collaboration in a complex world (Chesbrough, 2003). Open innovation can be interpreted from micro level and macro level (Yun, 2015), connecting to regional and national innovation supported by regional innovation policy and entrepreneurial ecosystem (Cooke, 2016). External innovation interaction among organisations is important for regional innovation potential (Cooke, 2002; Yun, Cooke, and Park, 2017; Yun et al., 2017). Meanwhile, ecosystem including innovation ecosystem and its boarder concept of business ecosystem has been explored in the last two decades across strategy and innovation disciplines to deal with dynamic environments, providing important strategic guidance to companies (Hou and Shi, 2021). Whilst open innovation strategies are mainly adopted by large firms or SMEs collectively, innovation ecosystem concerns the scale of innovation at national and regional levels, or with multiple players involvement.

The concept of ecosystem can be traced back to the early studies of business ecosystem, an economic community supported by a foundation of interacting organisations and individuals, where participants coevolve their capabilities and roles and tend to align themselves with the directions set by one or more central companies (Moore, 1993). Innovation ecosystem is regarded as a modular consisting of multilateral interdependence and as a configuration of activities defined by a value proposition (Adner, 2017). The focal firm approaches the alignment of partners and secures its roles, while providing a governance structure to deal with non-generic complementarities (Adner, 2017). This governance structure is not completely hierarchically controlled (Jacobide et al., 2018). Within ecosystem, four categories of organisations play distinct roles, keystone player, niche player, dominator and hub landlord (Iansiti and Levien, 2002). Specifically, a keystone player benefits the ecosystem by providing a platform for collaboration; a niche player contributes with unique capabilities; a dominator directly controls a large portion of the network; a hub landlord avoids taking control of the ecosystem while extracting the greatest possible value from it (Iansiti and Levien, 2002). Innovation ecosystem evolves alongside knowledge creation, development, transfer, and exchange among economic agents and non-economic parties such as technology, institutions, sociological interactions, and culture (Merican and Goktas, 2011). Thus, innovation ecosystem is a complex adaptive system which reacts to external disruption and absorbs opportunities (Hou and Shi, 2021).

At regional level, studies of innovation ecosystem also address the dynamic relationship between innovative actors, such as university, industry, government and society. This can be interpreted as the non-static non-linear models Triple Helix (Etzkowitz, 2003) and Quadruple Helix (Carayannis and Campbell, 2009). The Triple Helix model consists of an evolutionary process in which each helix of university, industry, and government keeps its distinctive characteristics while simultaneously assuming the role of the others in a non-static non-linear way (Etzkowitz, 2003). While traditional theories focus on the specific role of firm, university, and government, Triple Helix theory provides the dynamic connection among the innovative actors, involving a network of relationships (Etzkowitz, 2003).

A further developed model regards media and culture-based civil society as a new innovative

actor, forming the Quadruple Helix with combination of top-down university, industry and government policy driven innovation, and bottom-up society initiatives (Carayannis and Campbell, 2009). Moreover, the issue of public participation, social innovation, and responsibility has been highlighted in recent innovation ecosystem related studies (Liu et al., 2019; Liu et al., 2020, Liu, Shi, and Yang, 2022). Community management offers open participatory and distributed innovation processes, yet the concept of community in Triple Helix is still new (McAdam and Debackere, 2017). Meanwhile, the role of other actors apart from industry, university, government, and civil society in regional innovation ecosystem is not clear in the current Triple Helix framework.

2.2. Communities of Practice and Innovation

Knowledge in industrial fields can be shared within and between organisations through Communities of Practice (CoP) for practical purposes. The concept was originally adopted to explain learning (Brown and Duguid, 1991), and more recently innovation across work, organisational and spatial settings (Amin and Roberts, 2008; Franke and Shah, 2003; Muller and Ibert, 2015). CoPs are defined as “*groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis*” (Wenger, McDermott and Snyder, 2002, p.4). It is conceptualised as informal relations and understandings that develop in mutual engagement on an appropriated joint enterprise (Wenger and Snyder, 2000), as well as groups with the specific purpose to learn, create, and share knowledge (Wenger, McDermott and Snyder, 2002). Such situated practice is a source of knowledge formation (Wenger, 1998; Muller and Ibert, 2015). Based on the linkage between situated practice and learning, three dimensions of CoP are identified as mutual engagement, sense of joint enterprise, and a shared repertoire of communal resource (Wenger, 2000). From a social capital aspect, CoP are categorised as: 1) structural dimensions, meaning CoP can develop a network of individuals who share similar interests; 2) relational dimensions, referring to trust and obligations through the interpersonal interactions; and 3) cognitive dimension, meaning CoP can shape norms and values (Lesser and Prusak (1999).

CoPs exist within and outside organisations, spanning organisational boundaries and domains of specialist practice and knowledge (Sims, 2018). Inside organisations, CoP approach can reinforce innovative work processes, enhancing product and service quality, encouraging knowledge learning (Vidgen, Sims and Powell, 2013), establishing network and trust among members (Gongla and Rizzuto, 2001). Thus, CoP serve as an important information management infrastructure that enhances organisational innovation performance (Hung et al., 2007), and has a positive effect on knowledge management system (Choi et al., 2020). While most literature explores CoP as forms of knowledge sharing and innovation within firms (Wenger, McDermott and Snyder, 2002; Amin and Coherdet, 2004), a second strand of literature focuses on the relationship between firms and user communities (Muller and Ibert, 2015). For the latter, user-oriented CoP influences innovation, which is consistent with the concept of open innovation (Dahlander and Gann, 2010; Muller and Ibert, 2015).

Cultures and CoP are regarded as important sources that contribute to the emergence of innovative ideas (Muller and Ibert, 2015). By exploring science-based SMEs, Pattinson and Preece (2014) identify three types of CoP, apprentice-based CoPs to support individual learning, intra-organisational CoPs to facilitate internal knowledge sharing, and inter-organizational

CoPs. It is also noticed that though the conditions for forming CoPs e.g. joint venture are present, CoP may not emerge (Pattinson and Preece, 2014). Thus, there is an awareness that inter-organisational CoP either emerges organically or needs cultivation. In a broader sense, CoP can be generalised as knowing in action, a driver of learning and knowledge generation across different working environment (Amin and Roberts, 2008). Accordingly, there are different typologies of CoP based on the nature of knowing in action, namely, craft or task-based knowing, epistemic or high creativity knowing, professional knowing, and virtual knowing (Amin and Roberts, 2008). Thus, the nature of CoP is highly dynamic, and it is unhelpful to utilise CoP as proxy for all types of situated knowing (Amin and Roberts, 2008).

The role of group-derived innovation and CoP has been widely discussed in the literature (Matsumoto, Kasamatsu and Sakakibara, 2022; Malik, et al., 2021; Iskanius and Pohjola, 2016; Theodorakopoulos, Preciado and Bennett, 2012; Karlsen, 2010; Gausdal, 2008; Teigland and Schenkel, 2008; Braun, 2002). Despite this, there is a lack of consensus about how to evaluate the efficiency and effectiveness of CoPs (Fulgenzi et al., 2020) and the exact function of CoPs in the innovation process remains unclear (Muller and Ibert, 2015).

2.3. Research Gaps Identification

Current literature has provided theoretical foundation with concepts of regional innovation ecosystem and CoP. However, in general there is a lack of understanding of the relations between CoP and innovation (Ji, Sui and Suo, 2017). Extant literature is based on the assumption that members of CoP tend to have a similar background and share professional experience, skills, and knowledge together (Ji, Sui and Suo, 2017), whereas it is not clear how innovation takes place beyond a community's boundaries (Mullter and Ibert, 2015) or across industry sectors. Specifically, in the context where knowledge is not ready and requiring collaboration from various backgrounds in the form of inter-organisational CoP, it is important to explore details of innovation management. Thus, this study aims to explore how CoP functions in the regional innovation ecosystem with the context of promoting circular economy.

3. Research Scope and Method

The research question is “how can CoP approach cultivate regional circular economy innovation?”. To answer this, we adopt a qualitative research methodology to understand ongoing issues which are unexplored (Yin, 2018; Eisenhardt, 1989). The East Wales region of UK is the research scope and setting. Within this region, there is a long history of university-industry-government interaction in heavy industry, creative industries and healthcare sectors. Moreover, the Welsh Government has established sustainable development as its central organising principle, with the Well-being of Future Generations Act 2015 and the Environment Act 2016 providing a new sustainable development framework (Welsh Government, 2015; 2016). Moving to a circular economy, which eliminates waste by cutting down throw-away consumption and turning materials that would have been previously sent to landfill into a valuable resource, has never been more important (Constructing Excellence in Wales, 2017). Several CoPs are formed with government funding to connect individuals, firms, and institutions that have the potential to generate or accelerate circular economy knowledge.

To explore managerial and organisational process of CoP, case study is a suitable approach (Yin, 2018; Eisenhardt, 1989). Specifically, the case Circular Economy Innovation Communities (CEIC) in East Wales was selected. Semi-structured interviews were conducted from October 2021 to May 2022 with 15 key individuals from the CoP. This included 5 CoP organisers from universities and 10 CoP participants from industry. Each interview lasted around 1 hour, with questions covering interaction in and outside CoP, addressing key innovation activities, process, attitudes, achievement and challenges. Sample questions are: *What was the experience of your organisation in terms of circular economy before you joined CEIC? Do you do things differently now? What has been achieved so far for you and your organisation since joining the CoP? What are the challenges? What motive you to work with others inside the CoP?*

Furthermore, the research team participated three CEIC workshops and conferences from Feb to March 2022 to observe the process of knowledge creation among the CEIC members. In addition, secondary documents were studied including project proposal and interim reports provided by the CoP organisers. These enabled the triangulation and crosschecking of data sources (Yin, 2018; Eisenhardt, 1989), and increased data robustness. Thematic content analysis was conducted (Braun and Clarke, 2006) with key themes generated, actively categorised (Grodal, Anteby and Holm, 2021) and confirmed within the research team. The research team then arranged 2 follow-up informal meetings in July 2022 with the CoP organisers to get feedback on the findings.

4. Case Analysis

The Circular Economy Innovation Communities (CEIC) programme is a project launched in March 2020 and is fully funded by the Welsh European Funding Office with the purpose of promoting circular economy innovation. Specifically, it aims to create two distinct regional innovation networks or Communities of Practice (CoP) in the Cardiff Capital City Region and the Swansea Bay City Region. The project is led by Swansea University in partnership with Cardiff Metropolitan University. CEIC delivers an average of four cohorts (CoPs) per annum, that last approximately ten months, to practitioners from the public and third sectors in South Wales. The CEIC programme (see figure 1) introduces participants to circular economy principles and innovation tools and techniques. Each cohort forms a CoP around a theme, such as ‘decarbonation of housing stock’. By June 2022, the first four cohorts (CE innovation CoP) were completed with a total number of 56 participants.

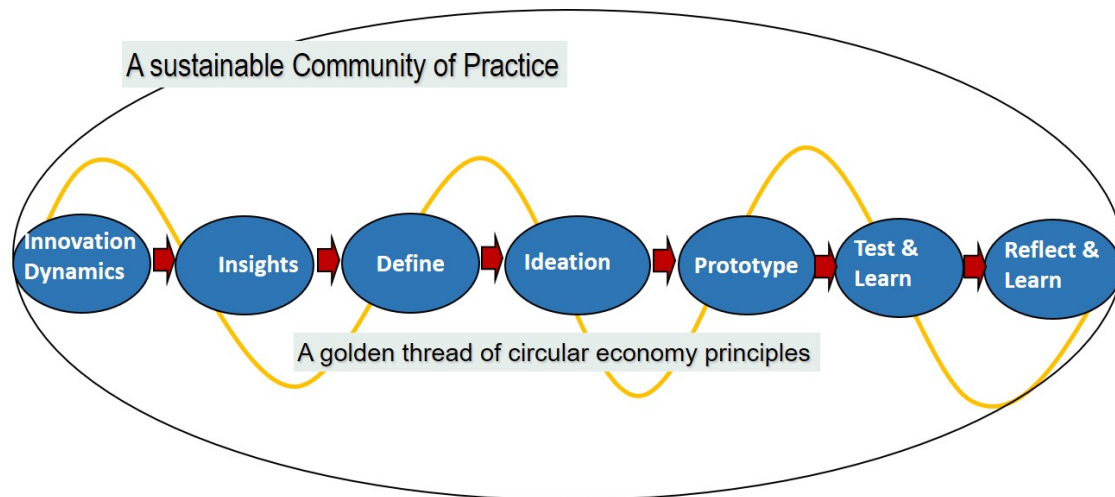


Figure 1. CEIC programme conceptual framework
Source: Walpole et al, 2022

Figure 1 outlines the conceptual framework of the programme, which develops a CoP from each cohort. The programme introduces participants to a formal innovation process in order for the participants to develop solutions to common challenges. The programme contains formal teaching and learning workshops, stakeholder engagement exercises, industry site visits, action learning, peer learning and support mechanisms, expert speaker master-classes and new product development (NPD)/new service solution (NSS) mapping and implementation support. There are approximately 20 practitioners in each cohort/CoP. The inter-organisational CoPs, within each cohort, are formed through a foundation day workshop and two-day residential which employs experiential learning exercises. Participants join a cohort to work on a general theme, such as ‘decarbonisation of housing stock’, and form into small challenge groups of 5-6 people to work on a specific problem common to them (i.e. ‘how might we develop a common approach to installation of external cladding’). The small group develop their problem statement by the end of the residential workshop. In the following monthly workshops the participants are supported to apply the design thinking process to their problem statement (see figure 1). The monthly workshops support the groups to develop their knowledge and skills of the design thinking process and apply the learning to their problem. Each month a new phase of the design thinking process is introduced to participants (see figure 1) and they are supported to iteratively develop the solution to their problem. The iterative process enables participants to enhance their solutions through the tools and techniques introduced during the workshops and feedback from peers and stakeholders. In addition, workplace exchange visits are encouraged, guest lectures and webinars are arranged to provide insights to participants. At the end of the 10-month programme the participants disseminate the findings at an ‘impact conference’ open to practitioners and stakeholders from across public service in Wales.

Interaction among the CoPs is through the CEIC spring and autumn conferences, open webinars and industry site visits. These mechanisms are designed to enable CEIC to support regional collaboration by introducing the inter-organisational CoPs to each other to share knowledge and provide a peer support network. Though each CoP project lasts ten months, participants create WhatsApp group and maintain close contact with each other. The network promotes collaboration between practitioners in a cross-sector innovation community and, in turn, enhances regional working through the operation, working closely with the Welsh Government and other funded operations. On completion of the CEIC programme, some participants jointly apply funding from local councils and the Welsh Government for circular

economy related new projects. In Dec 2023, the CEIC organisers are planning to publish a handbook for public service entities, as a record and reflection of the programme.

Beyond the traditional approach of transferring knowhow from university to industry, the CEIC project has developed several case studies. The CEIC programme builds on CoP approaches from two Welsh Government funded predecessor projects: 1) Open Innovation Communities of Practice led by Swansea University, a 9-month programme to support businesses to collaboratively develop new products and services and thereby jointly increase productivity across East Wales, and 2) Developing Innovation Performance of Firms and Supply Chain Clusters, a Swansea University led project funded by European Regional Development Fund.

Based on the case analysis, findings are from three aspects: CoP construct, CoP lifecycle, and the role of CoP in regional innovation ecosystem. The data structure is illustrated as Table 1.

Table 1. Data structure

Initial codes	Key themes	Contribution
- CoP organisers leading the project, and facilitating groupworks - CoP participants actively propose topics for discussion	Initiators	CoP construct
- CoP participants give guest lectures based on novel industry practice - CoP participants make changes to existing project in their organisations	Innovators	
- CoP participants forming WhatsApp group to influence more practitioners. - CoP participants present circular economy solutions to the public in the impact conference - CoP participants practice circular economy tools in their organisations.	Influencers	
- Intra-CoP learning and sharing knowledge - Inter-CoP forum, events and networking	Interactions	
- Predecessor CoPs provide managerial experiences, network and industrial cases; - Government funding with clear purpose; - Recruiting CoP participants from East Wales based on circular economy concerns	Formation	CoP lifecycle/evolving /dynamic process
- More CoP participants including industry guests joining in - Group learning and practicing based on circular economy principles and tools	Expansion	
- Stakeholder engagement and solution, which potentially contributes to the regional circular economy transformation	Transformation	
- CoP participants working on other projects together after the programme - Personal network reinforced continually - Successor CoP formed further jointly by government, university and industry	Renewal	
- Government funding CoPs - CoP participants jointly applying government funding, making impact on circular economy policies - CoP providing guidance to government policy design	Government	CoP connection with Triple Helix (regional innovation ecosystem)
- Universities coordinating intra- and inter- CoP learning and knowledge creation - CoP bringing practical knowledge back to curriculum development	University	
- Industry guest disseminating circular economy practice to CoP - CoP implementing circular economy principles and tools back to the industry - CoP developing handbooks for industry practice	Industry	

Sources: Created by the authors

5. Discussion: Communities of practice and regional innovation ecosystem

In this section, further discussion will be conducted from the aspects of CoP structure, CoP evaluation process, and the linkage between CoP and regional innovation ecosystem.

5.1. CoP Construct

The CEIC project shows a construct of multi-layer CoPs consisting of individuals across various sectors including healthcare, education, water, transportation, social housing. For each CoP or cohort, rather than specific industry sectors, common themes and challenges related to circular economy, e.g. decarbonisation of housing, are used to recruit CoP participants. The overall construct is illustrated as Figure 2.

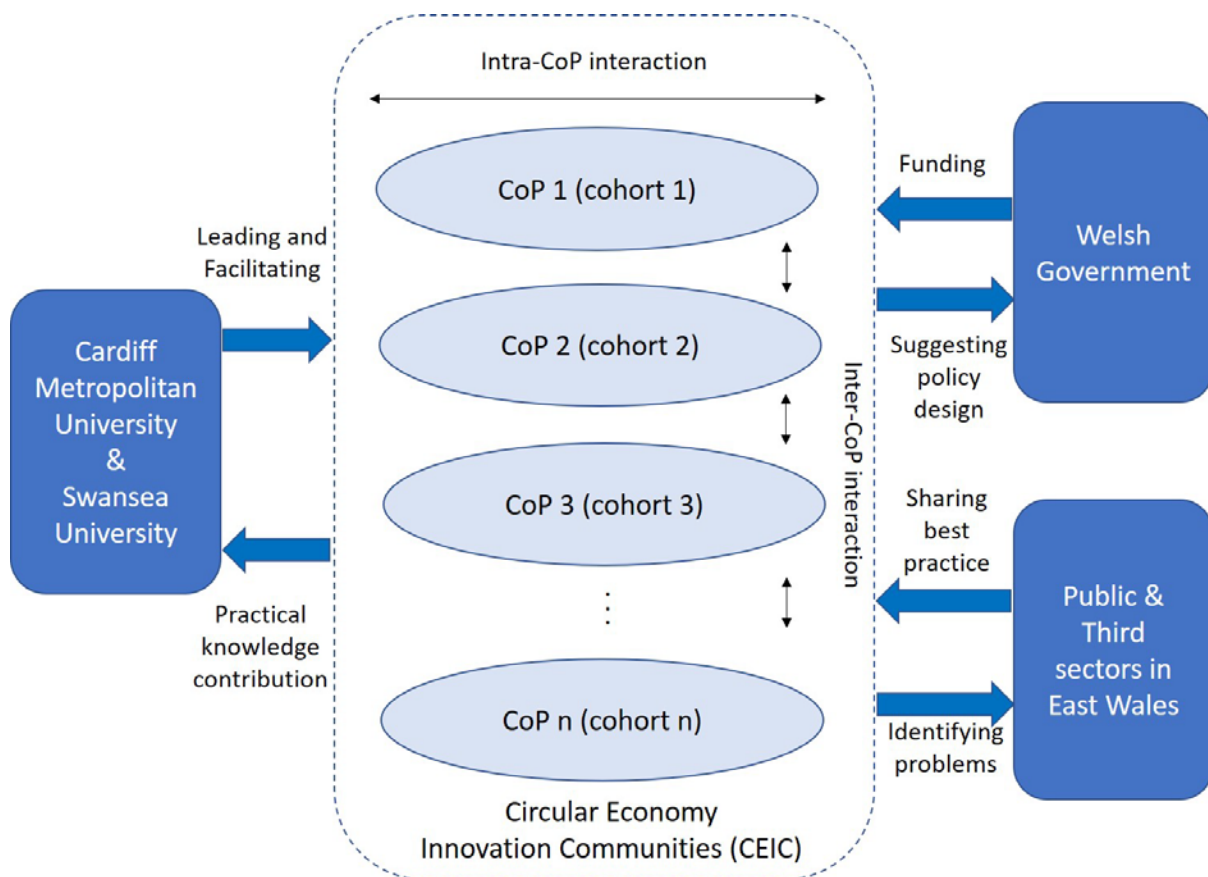


Figure 2. CEIC overall construct
Sources: Created by the authors

The CoP consists of initiators, innovators, influencers, and functions through intra-CoP and inter-CoP interaction mechanism. **Initiators** are universities and governments, namely Cardiff Metropolitan University, Swansea University, and the Welsh Government. They deliberately form the CoP with a clear aim of promoting regional circular economy. The role of initiator is similar to a keystone player (Iansiti and Levien, 2002) in an innovation ecosystem. CoP organisers are experienced academic staff from the backgrounds of project management, open

innovation and design-thinking, alongside a diverse expertise in terms of renewable energy, product design, decarbonisation, and supply chain. They introduce basic concept of circular economy, but leave the CoP participant to explore details with a self-governance structure. Rather than imposing learning within the CoP like a traditional university education programme, these initiators facilitate the interaction among CoP participants as a point of contact. According to the CoP organisers,

We want the public sectors to work effectively together to rethink how their resources are managed, shared in new, and existing projects and services so that they can maximise the financial, environmental and social benefits within the organisation. – CEIC website (<https://ceicwales.org.uk/>)

So the program is new to them and to most communities of practice as a vehicle for learning and sharing learning is is new. So yeah, we've come across a lot of challenges in terms of explaining what that is and overcoming their existing assumptions and knowledge about what what universities tend to deliver. So so I imagine at one end of the scale some of them are expecting a MBA type, MSc type module experience, and at the at the other end of the scale I imagine some are expecting and in the feedback we've I've had anecdotally and expecting a relatively informal...uhm what I would describe as a network where they come together, they talked through some of the challenges they experiences that experiencing, they go away and there's not much what I would call implementation or application of models. – an interviewee (CoP organiser)

Innovators are practitioners who are already experienced in circular economy related knowledge and practice, though some use the term sustainability other than circular economy. They join the CoP in the hope of developing further network, learning and sharing best practice, reflecting on existing projects, or identifying new innovation opportunities in their organisations. Though not CoP participants, companies such as Celsa Steel UK, Bluestone Resort, Orangebox give guest lectures on their innovative business model to implement the circular economy principles. Innovators are willing to take risks, promoting changes in the organisations. Innovators, including industry guest lecturers, play proactive role in the CoP, inspiring others with practical knowledge and experiences. According to our interviews,

Because it's embedded in a lot of the practice that I do anyway, I probably was a little bit ahead of other people, maybe in some of the things, but it was interesting...so the CEIC course for me, I suppose, reinforce the fact that, you know, just do something, test it. You know, if it works fantastic, but move on. And that's one of the things I'm really keen to try and promote...just changing other people perceptions and ideas really about doing that because I think people are very risk adverse and very reluctant to do that. – an interviewee (CoP participant)

I found useful to have guest speakers on the CEIC subject on the CEIC program and they covered subjects like about sustainability for building buildings and refurbishing buildings. So definitely look into that a bit more and we've got the names of the guest speakers who I found interesting and look at the work that they've done and how we can actually implement that

into what we're trying to achieve going forward– an interviewee (CoP participant)

Most CoP participants in this case have limited understanding of circular economy prior to the CEIC programme. They want to learn the circular economy concept, which can potentially solve problems in their organisations. They are in mid or senior management positions, and can influence changes in their organisations. Though not fully capturing the circular economy concept, they care about the environment and society. Thus, we identify their role as **influencers**. According to our interviews,

Coming to the CEIC, you obviously step out as somebody who cares about the environment and community. We wanted to get better understanding of circular economy...how can we do things differently. Then what tools can we use? How can we bring them back to our organisations...so we joined the CEIC. –an interviewee (CoP participant)

It is noted that the role of innovators, initiators, and influencers overlap. For instance, when it comes to specific areas, such as transportation and procurement, influencers can lead the discussion based on their specialities, and become innovators in the form of niche players (Iansiti and Levien, 2002) to promote innovation. Also, topics such as water safety sustainability are initiated by CoP participants to the CoP organisers, which changes the curriculum design.

The **interaction** mechanism inside a CoP is through group learning, formal teaching, on-site visits, and mini projects, whereas across CoPs, guest lectures, webinars, WhatsApp group, impact conferences, and informal networking events foster communication.

Based on the above analysis, the first proposition can be generated as follows.

Proposition 1. Cross-sector CoP can promote understanding of emerging practical knowledge, such as circular economy. Themes and challenges are important to drive knowledge creation and diffusion. There are different roles inside CoP in terms of knowledge management, including initiators, innovators, and influences. Interaction mechanisms within and between CoPs can be forums, events, networking and social media, which promote knowledge sharing.

5.2.CoP Lifecycle/Evolution process

The case study demonstrates four stages of CoP, formation, expansion, transformation, and renewal, alongside the evolving of circular economy knowledge and innovation activities. This is summarised as Table 2.

Table 2. CoP lifecycle

CoP stage	Circular economy related	Innovation related
Stage 1: Formation	Awareness of CE concept and tools	Knowledge transfer from university to CoP
Stage 2: Expansion	Identifying broad CE challenges, Identifying general CE elements	Best practice sharing within CoP, Intra-CoP learning and knowledge sharing
Stage 3:	Re-defining CE challenges,	Stakeholder (user, supplier) engagement,

Transformation	Solutions/changes to CE challenges	Co-production of knowledge within CoP, Inter-CoP learning and knowledge sharing
Stage 4: Renewal	Re-defining CE concept, Implementing CE concept/tools	Knowledge dissemination to stakeholders, Collaboration for innovation projects

Sources: Created by the authors

At Stage One (**formation**), the CEIC CoP is inspired by two predecessor CoPs, during which CoP approaches are successfully used to promote regional open innovation practice. With the government funding, universities play essential role by transferring knowledge to CoP participants through foundation day, residential day workshops, and circular economy principles and tools workshops. Single CoP are formed deliberately by the CoP organisers. Participants show various levels of understanding of this new knowledge, circular economy, as well as different expertise. According to our interviews,

We didn't know each other before the CEIC programme. We even wouldn't have chances to interact with each other...As a group of strangers, we shared common interest in circular economy, and faced similar challenges. We all wanted to achieve something, but didn't know what that is. – an interviewee (CoP participant)

At Stage Two (**expansion**), CoP grows with more participants joining in. Each CoP is given a circular economy related general challenge. To adopt the principle of design thinking introduced by the CoP organisers, CoP participants are required to develop empathy with the users of the new solutions. Thus, through brainstorming and engaging with stakeholders, CoP participants deepen their understanding of circular economy, and identify the real problems facing the users. For instance, they expand the knowledge economy from recycling, decarbonisation towards a holistic view. According to our interviews,

I had some experience of repair, but not much before the CEIC...Through CEIC we got to know each other, created this network. We want to share our knowledge, skill and funding opportunities. – an interviewee (CoP participant)

Circular economy is about integrate resource to support community wellbeing, we need to ask questions like who can we work with as partners? Who does what? It is a journey, not a destination. It is not something tangible like a product. – an interviewee (CoP participant)

At Stage Three (**transformation**), with the coordination from CoP organisers, CoP participants work as small groups, each creating a specific project from the general theme. They consider the economic, social and ethical aspects in designing solutions. For instance, one project is to explore the opportunities of reusing Welsh wool for building insulation. Another project team design a local repair café utilising library resources. CoP participates re-design the business processes including procurement, supply chain, and training and development, while the practical knowledge of circular economy is gradually in shape. They visit local organisations to test the methods and procedure. With trial and improvement, new knowledge and tools are co-developed aiming to transform the circular economy in East Wales. According to our interviews,

...At the beginning of the challenge, we wanted to save the world, we were stuck in the large scale of ideas...then we narrowed down to deliver something feasible, do something and move on. – an interviewee (CoP participant)

At the final stage, Stage Four (**renewal**), CoP members interact with boarder innovative actors, including local councils. They disseminate the knowledge through impact conferences where universities, industry practitioners, government officials, media and the general public are involved. They actively look for partners outside the CoP to advance the existing projects. CoP participants maintain closer personal relationship, having access to expertise across business sectors. Based on common interest, some start new projects or prepare for bidding for public funding relating to the circular economy. Thus, CoP shows increasingly more influence on the regional innovation ecosystem. Furthermore, a new successor CoP is formed, which can further unitise and advance the knowledge and tools developed from the CEIC CoP. As interviews indicate,

I've have had far more interaction with [anonymised individual] from [anonymised organisation] to work on Swansea Wellbeing project... So the personal interaction has been very much, I've enjoyed it. – an interviewee (CoP participant)

I have contacts that if colleagues come to me from Swansea Council, I'll give link them to colleagues from Carmarthen Council now because we've because of the the CEIC program I built, those built those links with those people. So that's been really useful. – an interviewee (CoP participant)

From the analysis, the second proposition can be proposed as follows.

Proposition 2. CoP is a dynamic process, going through formation, expansion, transformation and renewal stages. It can be built upon existing CoP which share similar approaches. CoP eventually forms formal collaboration, as well as personal network within a region. One CoP can also lead to a successor CoP with similar themes on a continuum.

5.3.CoP and Regional Innovation Ecosystem

Within the East Wales regional innovation ecosystem, **universities** play leading role in early stages of the CoP lifecycle. There is a high degree of knowledge transfer from Cardiff Metropolitan University and Swansea University to the CoP through formal learning and teaching. Nevertheless, universities mainly act as facilitators at mid and later stages, keeping in mind that CoP should be self-organised. Consequently, the degree of interaction between CoP and universities declines. As interviews reveal,

We formed the CoP for them (CEIC participants). But it is their communities, their engagement, they need to carry on, engaging with each other after the CEIC programme. – an interviewee (CoP organiser)

CoP participants come from **industries**. With the CoP expanding, industry also sends guest lecturers to engage with CoP, sharing best practice. At later stages, CoP visits industry sites to improve and verify the new knowledge and methods. In the end, CoP participants bring the knowledge back to their organisations, promoting circular economy programmes. Also, CoP

participants work across organisations for formal collaboration, thus transforming the industry in East Wales region. Meanwhile CoP organisers plan to write handbook to industry with a plan of 17 tools developed by the CoP. Hence, the interaction between CoP and industry increases from a low degree to a higher degree. According to our interviews,

There was a presentation and one of the CEIC program seminars by a housing association that has adopted the Carbon Literacy program. Uh, so I, uh, witnessed that and I've developed and implemented a carbon literacy program...So without that knowledge transfer from the CEIC program, I may or may not have had the inspiration to adopt a carbon literacy program. – an interviewee (CoP participant)

At the beginning, the Welsh **Government** funds the CoP, aiming for regional circular economy innovation. However, the government steps down as the CoP goes on. One reason is that more government interfering may restrict innovation, which happens at bottom-up level at mid and later stages of CoP. At the end of CoP lifecycle, participants actively approach government applying for funding to support circular economy practice. CoP organisers also work on guidance to policies that ensure resource-efficient delivery of public services, for example, providing guidance on retrofitting of social housing or use of renewable energy for public transport. Thus, the connection between government and CoP enhances again. According to our interviews,

It would be amazing if they (the Welsh Government) could become more involved in the communities of practice, but I think that might also limit interactions potentially in some way or discourage the participants from being truly open and collaborative. – an interviewee (CoP participant)

Table 2. Interaction between CoP and regional innovation actors

Innovation actor	CoP Stage 1	CoP Stage 2	CoP Stage 3	CoP Stage 4
University	High degree University → CoP	High degree University → CoP	Medium degree University ↔ CoP	Low degree
Industry	Low degree	Medium degree Industry → CoP	High degree Industry ↔ CoP	High degree CoP → Industry
Government	High degree Government → CoP	Low degree	Low degree	High degree CoP ↔ Government

Sources: Created by the authors

The degrees of interaction between CoP and regional innovation actors, namely university, industry and government are summarised as Table 2. From it, the third proposition is proposed as follows.

Proposition 3. Within the regional innovation Triple Helix, government and university can work together to deliberately form a CoP, especially when the knowledge is unknown, and needs cross-sector co-creation from practitioners. At later stages, CoP can in return lead the regional innovation ecosystem by reconfiguring industry processes and influencing government policy.

6. Conclusion

6.2.Theoretical Implications

The study explored the relations between CoP and innovation in the context of regional circular economy transformation. Based on an in-depth case study, there are mainly three findings: 1) CoP aiming for co-creating emerging new knowledge and practical tools consists of initiators, innovators, influences, and functions through intra- and inter- CoP interaction mechanisms; 2) CoP follows a dynamic lifecycle, starting with formation, then expansion, transformation, and renewal stages on a continuum; 3) CoP interact with Triple Helix innovation actors to promote regional innovation in different degrees alongside its lifecycle. Specifically, university and government lead CoP in the early stages. However, CoP can be self-managed at later stages, actively influencing the Triple Helix actors. While current literature focuses on CoP within organisations and user-based community engagement, our study provides in-depth details of inter-organisational CoP consisting of individuals from various industry sectors. It also links CoP with the Triple Helix framework from regional innovation ecosystem perspective and provides empirical evidence. The research has some limitation, as findings are drawn upon one single case study. Future research can engage with more cases to investigate the relations between CoP and innovation from a specific angle, e.g. lifecycle, to enrich the findings.

6.3.Practical Implications

While this project mainly contributes to the theories of innovation ecosystem and CoP from emerging knowledge creation and sustainability perspective, it also has practical implication. As is known, the post-pandemic economy needs to develop regional supply chains factoring in circular economy principles to reduce waste (Ibn-Mohammed et al., 2021). Multi-level approaches are needed where public and private sectors can actively engage to embed circular economy for practical development (Walpole et al., 2021). CoP offers such foundation for collaborative innovation. With the awareness of the construct and dynamic process of CoP, industries can better utilise it for their competence development, innovation process and collaboration opportunities during the circular economy transformation. They can explore the resource and social network through open innovation and inter-organisational CoP, developing new knowledge and solutions with across-sectorial expertise. Meanwhile, deeper capturing of the role of CoP in Triple Helix framework can help policy makers to develop appropriate support to tackle environmental challenges and thus transform regional circular economy.

Declaration of Conflicting Interests

The authors declare no conflict of interests.

Acknowledgement

The authors would like to thank all interviewees from the Communities of Circular Economy Innovation (CEIC) project. The authors would like to acknowledge the Society of Open Innovation: Technology, Market, and Complexity (SOI) for organizing the 2022 annual conference and special issue to help improve this paper.

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