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The Emergence of a High-Tech Entrepreneurial Ecosystem in the Cardiff Capital Region: The Role of the Region's Compound Semiconductor Industry

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Summary

The aim of this case study is to examine the emergence of a high-tech entrepreneurial ecosystem in the Cardiff Capital Region. In particular, it focuses on the role of the compound semiconductor industry and the main individuals – or ‘key human agents’ – that have played an important strategic role within this emergence. Such emergence is based on the creation of new industrial paths (or ‘path creation’). In this case it relates to the growth of high technology industries that can foster economic development in the region.

The study addresses the roots of entrepreneurial ecosystem emergence and the new industrial development paths that have been created as a result of this emergence. It is found that the agency of a small number of high profile entrepreneurs, and their vision and drive, led to slow but sure growth in the rate of entrepreneurship and economic activity in the region. It finds that entrepreneurs such as Drew Nelson played a fundamental role in this emergence, in particular the connections and networks they forged with the fledgling regional Welsh Government. Nelson’s vision was to build within the region a world-class networked cluster of semiconductor activity that would be globally leading in terms of innovation. Similarly, it is found that leading entrepreneurs in other industries (e.g., digital communications and life science) have played a vital role in the establishment of a high-tech entrepreneurial ecosystem in the region.

Within the field of digital communications and associated technologies, the entrepreneurial agency was led by Terry Matthews. Matthews sought to engender a cadre of new young entrepreneurs within the region focused on digital technologies and software through the establishment of a foundation focused on the development of entrepreneurial skills. Also Christopher Evans led developments in the fields of life sciences and biotechnology activity.

It is found that the impact of the entrepreneurial high-tech approach to development helped to change the economic narrative of the region which has led to a further wave of entrepreneurial and innovative activity that added further flesh (e.g., fintech, creative, and cybersecurity industries) to the emerging entrepreneurial ecosystem.

These developments represent a sign of the growing entrepreneurial confidence in the region and changing culture with regard to the notion of entrepreneurship. This is highlighted by the number of tech-based enterprises as a proportion of all enterprises within the region growing by 22.8% between 2010 and 2021, which compares to a UK average growth of 8.5%. Other positive indicators are that an independent survey of cities across the UK found that Cardiff was the most improved city between 2017 and 2020 for ‘good growth’, which is a composite measure of performance covering the availability of opportunity and levels of prosperity and well-being. Also, data for 2021 indicated that it was a record year for equity investment for small firms, with Cardiff being ranked the 10th highest equity investment hub in the UK, with the software sector having the largest number of deals.

The above analysis provides some important lessons as to the role of the emergence of entrepreneurial ecosystems as a catalyst for new path creation and economic development in a lagging region environment, with key components consisting of: (1) access to potential entrepreneurial agency; (2) the engagement of ‘enlightened’ local political agency; and (3) the formation of a collective agency across entrepreneurial and political agents as well as other relevant stakeholders.

It is concluded that the principal processes and mechanisms of ecosystem emergence in the region have consisted of the establishment of strategic networks between entrepreneurial and political agents. In this case, the compound semiconductor industry in the region and the strategic leadership and networks provided by Drew Nelson have proved to be crucial.

1. Introduction

This is the third in a series of case studies to support the CSconnected Strength in Places Fund (SIPF) project, funded by UK Research and Innovation. The first case explored the evolution of, and challenges facing, compound semiconductor clusters across Europe, this second case explored the role of firms in the Welsh cluster as inward investors and agents of regional economic change.

The aim of this third case study is to examine the emergence of a high-tech entrepreneurial ecosystem in the Cardiff Capital Region. In particular, it focuses on the role of the compound semiconductor industry and the main individuals – or ‘key human agents’ – that have played an important strategic role within this emergence. Such emergence is based on the creation of new industrial paths (or ‘path creation’), which in this case relates to the growth of high technology industries that can foster economic development in the region.

The concept of an ‘entrepreneurial ecosystem’, which consists of complex interactions between human agents (e.g., entrepreneurs) and an array of tangible and intangible components (e.g., networks, culture, and financial capital), has become a major means for both theorising and making policy decisions concerning entrepreneurship, innovation and economic development. Fundamentally, the conceptualisation of an entrepreneurial ecosystem is a manifestation of productive entrepreneurship and the role of human agents and their interdependent behaviour in complex and adaptive multi-scale networks that form systems forging innovation, value creation, prosperity, and well-being (Spigel, 2017; Stam, 2015).

There is a growing acknowledgement that positive regional development outcomes are based on the creation of new industrial paths that are able to foster and nurture both economic and social development (Frangenheim et al., 2020), thereby facilitating entrepreneurial activities. However, some less-developed regions have difficulties in developing these new paths. Meanwhile, evidence from some regions’ economic transformations suggests that that new regional path creation is connected with the emergence of an entrepreneurial ecosystem (Cao & Shi, 2021). However, the evidence base concerning this phenomenon remains scant, with little systematic analysis of either the processes and mechanisms of entrepreneurial ecosystem emergence or the manner in which such emergence can facilitate new path creation in weak regions and subsequently economic development. Given this, a focus on the Cardiff Capital Region is particularly pertinent as it moves from a relatively weak region competitively to one with increased capacity and capability to growth.

Given this knowledge gap, this case study aims to provide some in-depth consideration of the process of entrepreneurial ecosystem emergence and the mechanisms through which new path creation is fostered. Furthermore, it seeks to develop a mode of analysis that directly considers the role of human agency within these processes and mechanisms. As indicated above, this study focuses on the case of the Cardiff Capital Region, which has economically suffered for many years as a result of post-industrialism but has embarked on a process of new path creation embedded with a higher degree of entrepreneurialism in recent years. The study provides an analysis of this process based on the presentation of a narrative that addresses the roots of entrepreneurial ecosystem emergence and the new industrial development paths that have been created as a result of this emergence.

The rest of the study is structured as follows. Section 2 presents a review of the key concepts and their connections with regard to entrepreneurial ecosystems and new path creation in the context of the research questions indicated above. Then follows Section 3 that outlines the socio-economic and political context within which the case study is set. The case study analysis is presented in Section 4 and is followed in Section 5 by a discussion. Section 6 concludes with both the practical lessons and theoretical implications of the study.

2. Theory and Concepts: Entrepreneurial Ecosystem Emergence and New Path Creation

Ecosystems and Regional Development

The entrepreneurial ecosystem concept has risen in prominence over the last decade. Building on existing concepts such as industrial clusters, innovation systems, and business ecosystems, An entrepreneurial ecosystem is defined as a “set of interdependent actors and factors coordinated in such a way that they enable productive entrepreneurship within a particular territory” (Acs et al., 2017). In entrepreneurial ecosystems, organizations connect themselves to knowledge and allow the generation, dissemination and absorption of innovation. Thus, entrepreneurial ecosystems are now at the centre of efforts to promote economic development.

The entrepreneurial ecosystem concept as a lens for understanding and explaining new forms of industrial organization, innovation, and economic development includes the following interrelated aspects. First, it is a multi-scalar concept, incorporating not only the behaviour of firms and organisations but also the behaviour of human agents. Second, it is a network concept which emphasises the role of human and social networks as the fundamental building blocks of the dynamics of economic development. Third, it is a systemic concept which means that entrepreneurial ecosystems are a prime manifestation of systems that are complex, dynamic, constantly evolving, and possessing a nonlinearity in terms of the outputs and outcomes they generate (Spigel, 2020; Stam, 2015).

Mack and Mayer (2016) outline an evolutionary pattern consisting of four stages - birth, growth, sustainment and decline - and six core elements - policy, finance, culture, support, human capital, and markets. Emergence can be considered to encompass the stages from the initial birth, and the catalytic processes that underlie this birth, to the early growth stage whereby networks between key agents are strengthened, and emerging behavioural changes further encourage entrepreneurship, supporting infrastructure and policy to become more focused on new firm creation, with investors and capital being willing to take more risks.

Advanced regions tend to develop socio-economic systems within which macro-level behaviours emerge and also influence the micro-level interactions of the elements of these systems, which facilitate the creation of new order (Huggins & Thompson, 2022). At a regional level, the creation of new development paths may lead to the emergence of an entrepreneurial ecosystem (Roundy et al., 2018). Furthermore, the emergence of an entrepreneurial ecosystem forms part of the process of new path creation within regions, which stems from the role of human agency and the networks within which this agency operates (Korber et al., 2022).

Human Agency and Ecosystems

Human agency may be a vital component of the evolution of entrepreneurial ecosystems. It is clear that ecosystems are populated by agents, be they entrepreneurs or other actors, that influence the functioning of the system or otherwise. Human agencies (e.g., entrepreneurial agencies and political agencies) are vital to regional development. For instance, entrepreneurs are considered the central players in the creation and sustainment of the entrepreneurial ecosystem (Stam, 2015). Localised political agency, and the leadership it potentially offers through politicians, local authority professionals, as well as numerous other state and non-state agents, also act as key facilitators within the process of entrepreneurial ecosystem emergence (Spigel, 2020).

While these agents may operate in an individual capacity, their power to catalyse the emergence of an entrepreneurial ecosystem and subsequent new path creation is likely to lie with the collective agency they are able to form through the strategic networks they are able to carve.

Within this 'network' line of thinking, network formation and evolution, have long been acknowledged as playing a key role in mobilising diverse individual agency to establish a more collective agency that underlines the processes of new path creation in leading high-tech regions. In these cases, network formation and evolution lead to the increasing technological complexity of these regional economies, which ultimately allows them to grow faster than their counterparts (Mewes & Broekel, 2020). However, in lagging and peripheral regions, new path creation based on these network dynamics may fail because of the existing ties.

Concrete evidence of the process of overcoming these failures remains limited, especially within an entrepreneurial context, with one exception being Roundy's (2019) analysis of the case of the previously failing city of Warren in Ohio, whereby a number of transformative entrepreneurial and political agents developed new networks and entrepreneurial opportunities that have allowed a 'recrafting of the city's narrative' to encompass a more diverse range of businesses within the city. Although at a relatively nascent stage of new path creation, Roundy (2019) indicates that a new openness and diversity of behaviour is sowing the seeds for the emergence of an entrepreneurial ecosystem. This finding resonates with contemporary research on new regional path creation which indicates that such creation in regions is a function of the nature of key agents. These agents possess a high degree of transformative agency rooted in a tolerance for behavioural dissonance, openness and diversity, and who are situated within networks formed around a collective agency that is inclusive, flat and equitable (Huggins & Thompson, 2021).

Complexity in the Entrepreneurial Ecosystem

The evolution of collective agency within an entrepreneurial ecosystem will necessarily increase its complexity due to the diversity of behaviour across change agents seeking to promote interests that may not be, at least initially, harmonious (Du & O'Connor, 2021). Entrepreneurial ecosystems thus provide an ideal context to explore how to strategically manage the complexity and adaptability required to generate the innovation associated with new development path processes.

The concept of behavioural logic may explain the behavioural complexity within entrepreneurial ecosystems. Sarasvathy (2001) identified two different logics: causation logic whereby individuals plan their desired objectives ('ends') while defining the necessary 'means' required, or an 'effectuation' logic whereby individuals enact behaviour that defines (and redefines) their desired ends as they become more aware and knowledgeable as to what realistic ends can actually be achieved with their existing means. Fundamentally, processes based on causal logics relate to "a particular effect as given and focus on selecting between means to create that effect", while effectual processes take "... a set of means as given and focus on selecting between possible effects that can be created with that set of means." (Sarasvathy, 2001: 245).

In the entrepreneurial ecosystem context, a key argument of the causal-effectual logic dichotomy is that effectual behaviour is of particular value in entrepreneurial settings due to these contexts tending to have no clear development path (Sarasvathy, 2001). Due to the unpredictable and uncontrollable nature of entrepreneurial activity, human agencies in an entrepreneurial ecosystem are more likely to follow an effectual logic that is congruent with the nature of complex adaptive systems.

These agents interact within networks that grow into sustained system-wide elements producing nonlinear, emergent dynamics and generating creativity, learning, and adaptability, i.e. the acknowledged elements of complex adaptive systems (Galkina & Atkova, 2020). However, there is likely to be significant variety in the way by which these ecosystems emerge and evolve across different types of regions. This case study assumes that in lagging and peripheral regions, the ecosystem is likely to be reliant on a relatively small number of entrepreneurial agents, but who possess significant power to catalyse regional political agents to support an entrepreneurial approach and to formulate policies with key entrepreneurial agents.

3. The Cardiff Capital Region: Brief Context

The Cardiff Capital Region is an economically lagging area of the UK situated within the devolved wider region of Wales. It is formed of 10 local authority areas covering Cardiff, the main urban centre, and a number of other areas that largely form the traditional mining and post-industrial parts of Wales. It has a population of approximately 1.5 million people accounting for approximately 50% of the population of Wales as a whole, and similarly approximately 50% of the total economic output of Wales. The parlous state of parts of the economy are well documented. The economy persistently performs below UK-wide gross value added (GVA) per capita levels, with low average GVA per job (labour productivity) and low-wage employment being associated with industrial restructuring (as low-value services replaced traditional resource and manufacturing jobs).

The general business culture is seen to be weak, and across the small and medium-sized enterprise (SME) base there is a lack of a culture of entrepreneurship and innovation. An overemphasis on branch plants and foreign direct investment (FDI) in the past – rather than building up the capabilities of indigenous firms – is pointed to by some as a contributing factor. Overall, the performance of the economy has lagged that of the UK as a whole over the latter part of the twentieth century and into the twenty-first century.

Over the last two centuries, the region shifted from a mainly agrarian economy to one that was at the heart of the industrial revolution, largely due to the exploitation of its reserves of natural resources, principally coal (Morgan, 2012). From the latter part of the 1800s onwards, large extractive industries along with the manufacture of steel began to dominate the Welsh economy creating large numbers of new jobs and attracting significant numbers of migrant workers (Williams, 1950; Jones, 1984). However, the subsequent decline of these industries and the deindustrialisation occurring across the UK as a whole, left Wales, especially the Cardiff Capital Region, with deep structural weaknesses in its economy, which it is still struggling to overcome.

During the 1970 and 1980s employment in the once dominant coal and steel industries collapsed. Since then, the region has not been able to regenerate and convert itself toward a high-value service or advanced manufacturing economy with the same success as other parts of the UK, such as the South East of England. These issues remain particularly acute in the valley localities of the Cardiff Capital Region. In particular, the lack of a spirit of entrepreneurship has been linked to an industrial legacy that did not produce a ‘middle-class’ strata of Welsh culture and society with a capacity to even consider business ownership.

As part of the push by the UK government of the time for political devolution across the nation’s regions, the National Assembly for Wales became operational in 1999, with its elected Welsh Government becoming responsible for developing economic policies within the context of central UK policy frameworks. This has given policymakers in Wales more autonomy than previously, but the fiscal powers of the Welsh Government are limited, with no major tax raising powers, and with public finance continuing to be provided via a block grant from the UK Government. The key rationale behind the devolution movement was the perception of a “democratic deficit” in Wales based on the power of the London administered Welsh Office and a perceived lack of accountability.

In 2018 an economic plan came into being with a specific remit to address the challenges facing the Cardiff city region. The plan, known as the Cardiff Capital Region City Deal, is an agreement between the UK Government, the Welsh Government and the ten leaders of the local authorities. It includes plans for a £1.2 billion investment in the Cardiff Capital Region's infrastructure through a 20-year investment fund based on a collaborative programme to achieve regional growth and sustainability through investment, upskilling and connectivity. The key aim is to build a more connected, competitive, and resilient community and region.

Strength in Places Fund (SIPF) is a UK Research and Innovation scheme (UKRI) programme that helps UK regions to build on existing strengths in research and innovation to deliver benefits for their local economy. In June 2020, SIPF announced support for CSconnected, aiming to establish South Wales as home to the world's first compound semiconductor cluster. Given these developments, the emergence of an entrepreneurial ecosystem in the region can be viewed from the perspective of a place with more political autonomy and independence but also one with embedded socio-economic challenges.

4. High-Tech Entrepreneurial Ecosystem Emergence in the Cardiff Capital Region

The Agentive Roots of the Ecosystem

Tracing the roots of any system, especially an ecosystem, can potentially lead one into many different directions, but in the case of the emergence of a high-tech ecosystem in the Cardiff Capital Region the agency of a small number of high profile entrepreneurs cannot be ignored or overlooked. It is the agency of these entrepreneurs, and their vision and drive, that led to slow but sure growth in the rate of entrepreneurship and economic activity in three initial key sectors that underpinned the development of the ecosystem. This case study mainly focuses on the semiconductor industry led by Drew Nelson because this industry is one flagship sector in South Wales and a priority sector for the Cardiff Capital Region (we note here that compound semiconductor activities extend beyond the Cardiff Capital Region with Swansea University being an important part of sector activity).

Drew Nelson was the co-founder and for many years chief executive of the Cardiff-based firm IQE, which is one of the very few firms head-quartered in Wales that is listed on the public stock exchange. Drew Nelson and colleagues founded IQE (originally EPI) in 1988, and while its headquarters have remained in Cardiff, it has established a number of manufacturing operations around the world. While Nelson was already highly successful in the industry prior to the emergence of the ecosystem in the city region, his fundamental role in this emergence is through the connections and networks that were forged with the fledgling devolved Welsh Government.

Nelson's vision was to build within the region a world-class networked cluster of semiconductor activity that would be globally leading in terms of innovation. The cluster was envisioned to embrace the interests of industry, higher education and Welsh Government and provide an overarching structure for new product prototyping, project management, IP generation, skills development and training. The vision was seen to fit closely with Welsh Government strategic economic documents at the time including "*Economic Renewal: A New Direction (2010)*, and *Innovation Wales (2012)*.

The *Economic Renewal (2010)* document stressed the importance of broadening the skills base (p23) and: "Challenging our HE providers to become more deeply engaged in supporting future economic success of Wales through stronger relationships with business." There was an emphasis here on "more commercialisation of knowledge" and outcomes in terms of "new jobs and growth in existing and new companies arising from commercialisation of knowledge and research in higher education."

Nelson's vision was to effectively connect R&D expertise in both his firm IQE as well as members of the local supply chain and those housed within the local university sector. The dynamics of the cluster were considered to be based on the establishment of new start-ups alongside the attraction of investment from outside the region. Nelson and his team worked closely with officials from Welsh Government and later with the City Deal officials.

Policy and Framing the Ecosystem

Following the entrepreneurial vision shown by Nelson, an agreement between IQE, Cardiff University and Welsh Government led to the establishment in the region of the Compound Semiconductor Centre and the Institute for Compound Semiconductors at Cardiff University (which is a translational facility to help researchers and industry work together).

This was viewed by Nelson as a first step in an evolutionary process eventually leading to the development of large scale compound semiconductor manufacturing termed a ‘Global Foundry’. This Foundry would have the potential for development and manufacturing of CS wafers, with the Foundry embedded in Wales being at the centre of a cluster of firms using the technology.

The Compound Semiconductor Centre was founded in 2015 and is a prototyping facility allowing businesses and academics to demonstrate new technologies based on compound semiconductor materials. Since then it has begun to position itself as a new European network for product, services and skills development in compound semiconductor technologies. This has supported Nelson’s vision of a region possessing a vibrant cluster of semiconductor activity, which has since been branded as CSconnected. This project started in August 2017 but was boosted in November 2020 with funding through SIFP and has a total value of £43 million. This project aims to support South Wales’s compound semiconductor industry in creating 3,000 jobs by 2025, increasing its direct contribution to the local economy to £265 million per year, and improving skills among the local population.

The cluster has grown significantly and expanded to form its own emergent regional ecosystem with significant interdependencies across a range of organisations from the private sector, public sector, and academic and research organisations. According to the CSconnected Annual report, the estimated total employment of the CS cluster steadily increased from 1,345 in 2018 to 1,602 in 2021. During the period 2019 to 2021, the CS sector gross value added (GVA) increased by 55% and total impact on Wales increased by 54%. Another notable feature of the cluster’s development since 2015 is the investments in human capital and innovation, which have totalled more than £600m.

The cluster has achieved some significant success through the creation and attraction of four new high-technology companies featuring either greenfield investment or new investment into existing businesses (i.e., MicroLink Devices, Rockley Photonics Limited, Microchip Technology and MaxPower) in the industry (see Figure 1). MaxPower is a good example of a small company attracted by the CS ecosystem, but which has now become part of a much larger group (Vishay), partly as a result of its historical connections with the region (particularly Swansea University). The region is now also the location for a UK government-funded business acceleration facility (the ‘Compound Semiconductor Applications Catapult’), which acts as a focal point for stimulating new start-ups and the introduction of a number of incubation spaces to generate spinouts from local universities.

The cluster has also seen significant growth occurring in some individual companies, particularly SPTS Technologies (KLA) at Newport which in June 2021 announced that it was seeking to develop a new R&D and manufacturing HQ site at Imperial Park in Newport, which will allow for further expansion. The City Deal has acted as a champion for the development of this industry through both financial support and international exposure, and agreed to contribute £38.5 million towards the development of an IQE Foundry.¹ This acts as an anchor in the region for the high-end production of compound semiconductors and the sector as a whole in the region, which has already become the premier UK site for compound semiconductor production.

A further key part of the ecosystem is an evolving culture of collaboration. What has been observed is a strong cohort of individuals in the higher education sector, the private sector firms, and public sector who now take collaboration between themselves as a given. Specific examples of this new orientation are that the collaborators in the cluster now seek collective opportunities around skills development, to encourage new inward investment into the cluster and around R&D and innovation. There has also been a degree of defending and questioning partner actions and how these link through to the aims of the compound semiconductor cluster. Perhaps as importantly is a consistent narrative emerging among the cluster partners in terms of aims and objectives and links through to local productivity growth.

¹ See [The Foundry - Cardiff Capital Region](#)

Figure 1 CS Cluster new companies and investments

Organization names	Area of production/services	Date of incorporation in Wales
MicroLink Devices UK Ltd	Specializing in the design, development, and manufacture of advance solar arrays for spacecraft, aircraft, and terrestrial applications.	17/05/2019
Rockley Photonics Limited (US)	Photonics supplier of integrated optical chips and modules across multiple markets. Key markets healthcare, wearables, and machine vision.	09/09/2013 in the UK
Microchip Technology Caldicot Limited (US)	Development, manufacture and marketing of semiconductor integrated circuits.	05/10/1961
MaxPower Semiconductor (US) taken over by Vishay (US)	Silicon carbide power semiconductor products.	31/10/2022

Related ecosystem developments

Similarly, leading entrepreneurs in other industries (e.g., digital communications and life science) also play a vital role in the creation of connections with human agencies (including other entrepreneurial and political agencies). Within the field of digital communications and associated technologies, the entrepreneurial agency was led by Terry Matthews, the founder and Chairman of Wesley Clover International. Terry Matthews sought to engender a cadre of new young entrepreneurs within the region focused on digital technologies and software through the establishment of a foundation (the Alacrity Foundation in 2010/11) focused on the development of entrepreneurial skills. Matthews worked with the Welsh Government's then business minister to explore the formation of this foundation and a strong rapport between both clearly developed.

In the field of life sciences, much of the entrepreneurial impetus has come from Christopher Evans, who is a serial entrepreneur largely in the field of life sciences. His vision was to establish the region as a centre for life sciences and biotechnology activity that could begin to compete with the UK's existing hot spots of Cambridge and London. Evans was asked by the Welsh Government to chair a Life Sciences advisory board that would craft a strategy for advancing the industry with start-ups at the heart of this strategy and venture finance being the means of helping to stimulate their establishment and the expansion of these new firms.

These connections between entrepreneurial and political agencies were critical in catalysing a number of new entrepreneurial initiatives that were at the vanguard of a wider shift toward a high-technology entrepreneurial policy focus not only for the City region but also for Wales as a whole. The Cardiff Capital Region established in 2020 an *'Industrial and Economic Plan'*² to increase regional competitiveness globally with all these sectors benefitting from it. This plan is promoting a new way of working within the region, with UK Government, Welsh Government and local government working together and in partnership with the private sector, Higher Education and Further Education institutions, third sector and other public sector bodies on boosting productivity and accelerating sustainable, competitive and inclusive growth.

Within an investment and intervention framework, several key sectors such as CS, Fintech, artificial intelligence, and life science are priorities to be supported. The Cardiff Capital Region city deal works in partnership with education and training providers to support scientists to exploit the potential of the new industries and derive added value from traditional industries; business leaders to obtain high-quality training; younger entrepreneurs to develop, current colleges to nurture local talents. New infrastructure has been planned to fit future needs. The South Wales Metro, which is the "back bone" for the Plan, targets have been set to create 25,000 new jobs, achieve a 5% uplift in GVA and leverage £4 billion additional investment capital. Meanwhile, digital infrastructure will be also developed.

Changing the Regional Narrative

It is clear from the above that a small number of visionary entrepreneurs play a vital role in the emergence of an entrepreneurial ecosystem in the Cardiff Capital Region, in which entrepreneurs work with government, higher education, and other public sectors. Not only these visionary entrepreneurs but also other sectors benefit from the more developed ecosystem. In this way, it can be argued that this 'win-win' model of regional economic development represents a shift away from the often winner-loser models of development based on solely seeking external foreign direct investment that may result in negative impacts on incumbent firms operating in lagging regions. The impact of the entrepreneurial high-tech approach to development helped to change the economic narrative of the region, particularly through the role of leading entrepreneurs in shaping the strategic management of the region. This led to a further wave of entrepreneurial and innovative activity that added further flesh (e.g., fintech, creative, and cybersecurity industries) to the emerging entrepreneurial ecosystem.

In relation to fintech, as the city of Cardiff has increased its competitiveness and become buoyed by the City Deal finance, it has grown in importance as a commercial and business centre. As part of this development the fintech sector has emerged as a rapidly growing area of activity, which has resulted in the establishment of FinTech Wales, which is an accelerator programme based on developing proof of concepts for partners and access to over £100,000 funding. Entrepreneurial activity in the creative industries, particularly the media sectors, has also accelerated rapidly in recent years. With the support of the Welsh Government, a significant number of new start-ups, particularly in the area of film and TV production, have been established. Following strong growth in the past 10 years, the region is now the third largest film and TV cluster in the UK behind only London and Manchester.

² See [ccr-industrial-and-economic-growth-plan-english.pdf \(cardiffcapitalregion.wales\)](#)

The cybersecurity sector has emerged in the more hinterland areas of the Cardiff Capital Region. This largely resulted from the leading player in the region, Thales, locating their National Digital Exploitation Centre (NDEC) in Ebbw Vale in Blaenau Gwent. This has some commonalities with the Compound Semiconductor Foundry concept visioned by Nelson with the NDEC providing small firms with the infrastructure to test their and develop digital concepts. Since then a cluster across the region has emerged with a number of start-ups. Some of these have emerged from two local universities. Furthermore, it is interesting to note that the fintech sector is an important customer for the local cybersecurity industry.

New Path Creation

The emergence of new activities in the region in the fintech, creative, and cybersecurity sectors indicates the continuing evolution of the region's entrepreneurial ecosystem and the new economic paths being created. They represent a sign of the growing entrepreneurial confidence in the region and changing culture with regard to the notion of entrepreneurship.

Building upon the changing narrative outlined above, there is also growing confidence among regional policymakers. While entrepreneurial policy responses to economic development challenges necessarily involve a certain level of inherent risk, it is increasingly acknowledged they are those most likely to create long-term opportunities through new venture generation, new job creation and improved productivity. Clearly, new venture generation is the start of this process but ideas, visions and investments into the high-tech entrepreneurial ecosystem are bearing fruit with the number of tech-based enterprises as a proportion of all enterprises within the region growing by 22.8% between 2010 and 2021, which compares to a UK average growth of 8.5%.³

Clearly, it is still early days for the region, and its entrepreneurial ecosystem remains in its emerging stage, with issues of geographic dispersion, scale, resilience, and adaptability. Nevertheless, as well as the growth in enterprises highlighted above, there are also a number of other positive indicators. For example, an independent survey of cities across the UK found that Cardiff was the most improved city between 2017 and 2020 for 'good growth', which is a composite measure of performance covering the availability of opportunity and levels of prosperity and well-being.⁴ Also, data for 2021 indicated that it was a record year for equity investment for small firms, with Cardiff being ranked the 10th highest equity investment hub in the UK, with the software sector having the largest number of deals.⁵ These positive indicators are still very much a measure of a journey that is beginning, but suggest that the development of a region with a growing density of the principal components of an entrepreneurial ecosystem are not only emerging but also having a beneficial impact.

³ <https://www.ons.gov.uk/aboutus/whatwedo/paidservices/interdepartmentalbusinessregisteridbr>

⁴ <https://www.pwc.co.uk/industries/government-public-sector/good-growth.html>

⁵ <https://www.british-business-bank.co.uk/small-business-equity-tracker-2022/>

5. Lessons for other Regions

The above analysis provides some important lessons as to the role of the emergence of entrepreneurial ecosystems as a catalyst for new path creation and economic development in a lagging region environment. It further connects the literature concerning entrepreneurial ecosystems with the contemporary literature on regional development especially that focused on the role of human agency within the processes and mechanisms of such development. It is clear that lagging regions can begin to revitalise themselves through an entrepreneurial approach. However, this process is likely to be contingent and dependent on a number of important components, all of which relate to the notion of a place-based entrepreneurial ecosystem. **In this respect, key components exemplified in the case of compound semiconductors, consist of:**

(1) access to potential entrepreneurial agency

(2) the engagement of 'enlightened' local political agency

(3) the formation of a collective agency across entrepreneurial and political agents as well as other relevant stakeholders.

It is the harnessing of this agency that allows a broader recrafting of the economic development narrative of a region by the fostering of entrepreneurship in a range of higher tech and more productive industries through new path creation. In this sense, the process of collective agency formation is a vital manifestation of the emergence of an entrepreneurial ecosystem.

Within any lagging or under-developed region, the beginnings of economic revitalisation are likely to lie with the capability to engage existing entrepreneurs in the process of development. Furthermore, these entrepreneurs will require the necessary agency in the form of the influence, power and leadership to stimulate behavioural change within a region. The Cardiff Capital Region case study illustrated above indicates that these agents are likely to be most effective when they have a potential 'stake' in ecosystem formation through the growth of markets and opportunities within the industries they operate. It is logical to assume that the more economically weak a region is, the less likely it is to have a significant pool of relevant entrepreneurs to access, especially those located within the region. Therefore, ecosystem emergence may involve entrepreneurs both within and outside a region provided they have some form of social, cultural and/or economic connectivity with the focus region.

As this study has shown, the actual number of entrepreneurs initially involved can be quite limited as long as they possess the necessary agency to effectively form new networks and engage with the local political agents. Indeed, perhaps the most critical part of entrepreneurial ecosystem emergence in weak regions is the capability and capacity for entrepreneurial and political agents to interact in a meaningful manner. This should not be taken for granted since entrepreneurs may be addressing regional development challenges from an effectual logic, while politicians and policymakers are more likely to come at these from a causal logic.

Given this, it is a matter of integrating these differing development logics whereby entrepreneurs have an understanding of the constraints and expectations within which political agents operate, as well as these political agents being aware of the motivations and expectations of entrepreneurs. It is this understanding and awareness that allows the formation of a collective agency whereby an intersection of common goals and visions emerge. This collective agency begins to extend beyond the initial entrepreneurs and policymakers to a wider community of agents consisting of additional entrepreneurs, firms, financiers, universities, and others that create the networks underpinning the emergence of an ecosystem.

In terms of the theoretical perspective on this study, it is difficult to argue that these components of ecosystems are generalisable enough to propose a common framework of ecosystem emergence or even a common theory of ecosystem emergence in weak regions. However, it can be argued that adopting an agency-based approach to analysing such emergence highlights the importance of key human actors in such emergence alongside the role of particular resources, capital and institutions (Korber et al., 2022). Furthermore, the interaction between agents and the formation of collective agency provides a means for analysing the 'relational' aspects that many scholars have argued are crucial to conceptualising entrepreneurial ecosystems (Spigel, 2017). Within this relational framework, entrepreneurial ecosystems are rightly portrayed as an organisational form with the many known features of complex adaptability, ranging from non-linearity to self-organisation and non-deterministic behaviour (Roundy et al., 2018).

The primacy for emergence forms part of the key characteristics of complex adaptive systems in the form of the behavioural change stemming from the interaction of agents within a system (Galkina & Atkova, 2020). The mechanisms behind this behavioural change have tended to remain something of a black box both within the complex adaptive systems and entrepreneurial ecosystems literature. In light of this, the idea of a collective agency emerging across often disparate individual human agency provides a means for better understanding how change is fostered and tolerated, as well as how these changes provide the impetus for the concrete programmes and initiatives that lead to ecosystem emergence.

These understandings can be further advanced by a greater meshing of the literature across the entrepreneurship and regional studies spheres of scholarly endeavour. In particular, the notion of the effectual and causal logics operating within the networks framing entrepreneurial ecosystems provides a useful framework for regional studies scholars in terms of examining the dominance or predominance of particular forms of agentic behaviour impacting upon and influencing the evolution of regional development policies and interventions (Kerr and Coviello, 2020). Similarly, after many of years structural theories of regional development, regional studies has more recently taken a more 'agentic turn' with new theorisations addressing the role of particular forms of agency in catalysing the industrial path creation from which regional development stems (Huggins & Thompson, 2022).

Much of this agentic thinking originally stems from ideas within evolutionary economics, and this now forms part of the growing field of evolutionary economic geography and the more nascent field of behavioural economic geography (Huggins and Thompson, 2021). It would appear that much of this thinking can be applied to the field of entrepreneurship. Evolutionary theories of entrepreneurship have stuttered their way for a number of years (Malerba and McKelvey, 2020), but none has fully grasped a comprehensive understanding as to how entrepreneurs play a role in the evolution of regions nor the role of place in influencing entrepreneurial forms. As the 'entrepreneurial ecosystem' idea continues to advance from a useful metaphor to a more fully fledged conceptual lens it can act as a framework for encompassing evolutionary entrepreneurial thinking.

6. Conclusions

In conclusion, this study has shown that lagging regions such as the Cardiff Capital Region can trigger a process of development through new path creation stemming from the emergence of an entrepreneurial ecosystem. The principal processes and mechanisms consist of the establishment of strategic networks between entrepreneurial and political agents. In this case the compound semiconductor industry in the region, and the strategic leadership and networks provided by Drew Nelson and his counterparts in areas of high-technology, have proved to be crucial.

Such networks facilitate the formulation of new and novel entrepreneurial initiatives and interventions that attract significant investment and engagement by the local business community, policymakers and organisations such as universities. This process is initially underpinned by a relatively small pool of human agents, such as Nelson, but as success begins to emerge the associated networks expand and cascade to a larger pool of agents, in particular new entrepreneurs. Particularly important here is how this expanded network acts to look for collective opportunities around skills development, R&D and new entrepreneurship to promote the aims of the cluster. In the case examined in this study, the processes led to new path creation through a deliberate and strategic focus on catalysing new entrepreneurship across a range of high-technology industries, including compound semiconductors. Therefore, the emergence of an entrepreneurial ecosystem started to change the economic trajectory and future evolution of the region.

Finally, and as indicated above, this study is limited to a single case study and as regions around the world seek to establish their own entrepreneurial ecosystem it will be important to map variety in the processes, mechanisms and agency across these regions. This paper provides one means by which to frame a comparative analysis that can inform both scholars and policymakers as to potential routes toward an entrepreneurship-focused approach to regional development.

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