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Spaces of Novelty:

Can Universities Play a Catalytic Role in Less Developed Regions?

In: Science and Public Policy

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Abstract

Over the past few decades Universities have been asked to become ever more involved in the development of their regions and countries, through knowledge dissemination, contribution to policy debates or even by becoming leaders in stakeholder coalitions. However, as has been

often pointed out, for Universities to have an impact on regional fortunes it is necessary to have an appropriate innovation ecosystem, which is often lacking in less developed regions. We approach this issue by discussing the three interrelated dimensions of knowledge supply, demand and translational activities, through two case studies of University-business engagement in Wales. We also distinguish between narrow forms of engagement, based strictly on the commercialization of knowledge, and contrast them with broader forms of engagement. Finally, we discuss the practical and normative challenges associated with these interactions, such as the danger of appropriation of public resources by private organisations.

1. Introduction

Over the past decades Universities have been encouraged, and in some cases coerced, to become more active players in regional and/or national innovation systems (Kohoutek et al 2017; Uyarra 2010). The promotion of University engagement with external partners is of course not a new phenomenon, as demonstrated for instance by the experience of land-grant institutions in the 19th century USA (Christopherson et al 2014). However, it has now become ubiquitous in both developed and developing countries to expect most, if not all, higher education institutions to actively embrace this agenda. The issue is that engagement has multiple, and sometimes, contradictory meanings, ranging from universities as civic partners within a wide and diverse network of stakeholders working towards broad development goals, to universities as providers of knowledge that can be commercialised for economic gains (Goddard and Valance 2013). Cutting across these debates about the nature of engagement, a different strand of literature focuses on the specificities of university engagement in the context of less developed regions (LDRs), where both their internal (to the university) characteristics, and their socio-economic environment tend to pose unique challenges (Kohoutek et al 2017; Pinheiro et al 2016; Pinto et al 2015; Trippl et al 2015). This paper sits at the intersection of these two debates. It draws on two case studies which are narrowly concerned with the commercialisation of knowledge and examines which factors can determine the success of these type of initiatives. At the same time, it uses these examples to debate the limitations of such a narrow understanding of engagement in LDRs.

First, this paper will address the issue of engagement through a theoretical approach that distinguishes between the *supply-side*, *demand-side* and *translational* dimensions of University-business interactions. In this paper, supply-side refers to the quality and appropriateness of knowledge being produced by universities, in terms of its capacity to be commercialised by firms (Bonaccorsi 2017, Laursen et al 2011). Demand-side refers to the presence in the region of firms with absorptive capacity to access, absorb, and exploit the knowledge produced at universities (Cooke and Morgan, 1998; Huggins and Kitagawa 2012; Pinto et al 2015). The translational dimension refers to the existence of intermediaries which can bridge information asymmetries and facilitate this process, such as technology transfer institutes (Degroof and Roberts 2004; Pugh 2017; Strinivas and Viljamaa 2008). The combination of these elements in a regional innovation system is essential if universities are to play a catalytic role as generators of knowledge which can lead to enhanced innovation in firms. In LDRs, however, any of these three dimensions may be underdeveloped or subject to institutional constraints. By unpacking each in turn, this framework will allow greater analytical depth in explaining the interaction of different factors that prevent universities from having a catalytic role on economic development in these regional contexts.

It is important to state that the separation of these three elements is useful only for analytical purposes, since systemic interactions between partners is of course dynamic and non-linear. As such our goal is not to suggest that knowledge flows unidirectionally from universities to firms through translational entities, but merely to highlight that the characteristics of different entities matters for the functioning of the system (Vallance, 2016). Also, we use supply-side, demand-side and translational activities as broad categories that allow us to link up with debates in the wider literature, though we recognise that in dynamic knowledge interactions both partners can assume different roles and become either suppliers or demanders of knowledge at different moments in the innovation process (Flanagan and Uyarra 2016).

Second, the paper builds on this discussion to open up the ‘black-box’ of the university as an institution with multiple roles and values, one that cannot be reduced to its "entrepreneurial function". By doing so, it problematizes conventional models of the Triple Helix, where it is assumed that engagement between the three pillars (Universities, Government, Private sector) is unproblematic from practical and normative points of view. Empirically, the paper presents two case studies of university-business engagement in Wales in the fields of renewable energy and compound semiconductors. These case studies signal a discernible break with

previous modes of university involvement in the regional innovation process in Wales, where too much attention had been paid to political priorities and too little attention to the capacity of the *regional ecosystem* to support the commercialisation of knowledge from the university sector (Morgan, 2013). They also highlight the shortcomings of a university engagement model aimed towards commercialisation and entrepreneurial activity, a model which predominates in the UK context.

2. Universities and innovation systems

The translation of advanced knowledge into innovation outputs is a complex, dynamic phenomenon, which depends on the existence of a 'thick' regional innovation system. According to Trippl et al (2016) thickness (or thinness) can be both organisational and institutional. The first refers to the existence of organisations, including those producing knowledge (e.g. Universities), those exploiting it (predominantly private firms) and support institutions, such as the public sector or trade unions. The second, "is defined as the presence (absence) of both formal institutions (laws, rules, regulations) and informal institutions (such as an innovation and cooperation culture, norms and values) that promote collective learning and knowledge exchange" (Trippl et al 2016, pp. 27). In this typology, only those regions that exhibit thickness in both aspects would be considered to have a developed innovation system, with all the others exhibiting some type of dysfunction. It is important to bear in mind, that wealthy regions can be categorised as having less developed regional innovation systems, as is the case of many peripheral northern European territories.

Looking specifically from the perspective of Universities and their role within a RIS, it is also useful to distinguish between typologies of HEI, which reflect among other things their primary strengths and types of engagement. According to Kohoutek et al (2017) there are three main types of University operating in LDRs: 1) classic, research intensive universities, hosting a large variety of departments and disciplines, offering both teaching and (primarily) basic research. Their emphasis on operating and the cutting-edge of scientific and technological knowledge means that they are less likely to engage locally and to choose instead to embed themselves in international networks. 2) Vocational Universities or colleges, offering both teaching and mostly applied research, with strong local engagement

with local government or industry. 3) Vocational universities or colleges that have limited research capacity and primarily focus on teaching activities, including through staff and student mobility, and also tend to be locally engaged.

Bringing together both elements would suggest that in 'thinner' organisational and/or institutional environments it is probably type 2 and 3 Universities which are most likely to be engaging with local stakeholders, especially if the private sector does not include firms with innovation capabilities that would allow them to take advantage of the knowledge produced in type 1 universities. However, the debates on knowledge commercialisation tend to focus instead on the first type of University, which are the ones expected to generate the sort of disruptive or transformational knowledge that has the potential to generate higher economic gains or even new sectors of economic activity (Etzkowitz and Leydesdorff 2000). This paper argues that this is in part due to an insufficient recognition of the complex systems which must be in place for such processes to take place.

2.1 Advanced knowledge and commercialisation

Building on the RIS concept, we approach this issue by distinguishing between supply-side, demand-side and translational dimensions of university-business engagement. The first refers to the capacity of universities to produce and disseminate knowledge which is relevant and useful to private firms. This capacity allows universities to have a generative role in regional development, a perspective influenced by the triple helix model (Etzkowitz and Leydesdorff 2000), and which argues that higher education institutions (HEIs) are primary agents in an innovation system. This means that they lead processes of economic development through an offer of services that allow firms to capitalise on boundary-spanning knowledge. These services include the creation of science parks, start-up incubators, access to research centres and, in some contexts, an active participation in firm governance. It is this approach which feeds the drive in HEIs towards the creation of spin-offs and the monetisation of intellectual property through patenting and knowledge licensing (Degroof and Roberts 2004)

A different approach conceives of universities as having a predominantly developmental role (Gunasekara 2006). As argued by Gunasekara (2006), these are not mutually exclusive roles, though they emphasise different forms of engagement. The developmental role points towards a participation in broader regional development processes, with less emphasis on strictly entrepreneurial activities (Uyarra 2010). Here the goal is to encourage universities to

adapt their research and teaching activities to the knowledge needs of each region (Pugh 2017). This involves paying more attention to the supply of human capital and to issues of student recruitment and retention and to investments in networking with external regional partners which would help to align strategies and interests (Marques 2017). It also examines experiences of engagement with a broader set of stakeholders, including representatives from civil society, and discusses how universities can act as 'institutional entrepreneurs' with the capacity to lead regional development processes (Raagmaa and Keerberg 2017). This approach could therefore be said to focus more on the medium to long-term, rather than on rapid knowledge capitalisation, and to include developmental goals that go beyond narrowly economic concerns (Arocena et al 2015; Goddard and Vallance 2013; Pugh 2017).

In this paper it is argued that the developmental rather than generative role is more attuned to the experience of LDRs, but that, in countries such as the UK the latter tends to dominate policy narratives and instruments. It will also be argued here that this can be problematic. For instance, as demonstrated by Bonaccorsi (2017), there are fewer high-quality University departments in European LDRs, in comparison to more advanced regions. Equally important, these high-quality departments tend to specialise in areas of knowledge (such as life sciences) which are not relevant for the economic specialisation of these regions. Turning HEIs into engines of growth in these contexts would therefore imply a medium-term process, which would increase the quality of knowledge produced, a factor that firms tend to value when choosing whether to engage with universities (Laursen et al 2011). It would also imply a slow process of regionalisation and adaptation of universities to become more sensitive to the needs of regional actors, by investing in areas of knowledge that are more relevant to local actors or creating incentives that encourage academics to build local networks (Boucher et al 2003; Marques 2017).

The activities and internal logic of universities are however only one dimension shaping their engagement with external agents. Equally important is the demand from these agents, particularly firms, for the knowledge which HEIs produce (Huggins and Kitagawa 2012, Laursen et al 2011; Pinto et al 2015). In more formal terms, firms need sufficient levels of *absorptive capacity*, which means the capacity to appreciate the value of external knowledge, to incorporate it into the firm and to apply it to commercial ends through innovation (Cohen and Levinthal 1990). The higher the complexity of the knowledge produced, the higher the capacity demanded from firms, particularly when dealing with emergent technologies, since

at this stage technology is less codified and standardised (Perez 2002). As a result, firms specialised in high-tech activities, or with high levels of innovation (measured for instance by the existence of an R&D department), tend to be more capable of accessing and absorbing advanced technology (Li 2011; Huggins and Kitagawa 2012; Pinto et al 2015), thereby creating a virtuous circle of increasing absorptive capacity and innovativeness. Since these firms tend to concentrate in more advanced regions, this generates a problem of insufficient demand for advanced knowledge within LDRs (Bonaccorsi 2017; Camagni and Capello 2013). Size of firms is also an important variable (Pinto et al 2015) in explaining propensity to engage with HEIs, which again tends to favour more advanced regions where larger firms tend to be headquartered (Iammarino and McCann 2013). Even when LDRs are host to large production facilities from multinationals, if they operate only as branch plants with limited autonomy their interaction with the local innovation is likely to be limited (Kramer and Diez 2012).

As mentioned earlier, though we use the term knowledge demand we recognise that University-business interaction is a systemic process, which involves feedback loops between organisations (Pinheiro et al 2016). HEIs can develop specific research strengths as a result of firm interaction, or emphasise specific types of research activities. Firms can also collaborate with Universities in areas such as curriculum design and training, which both help align the activities of HEIs with the regional economy but also help to integrate young graduates into the labour market (Healy et al 2014). Nonetheless, the major point stands that for this to happen firms themselves need to have specific capabilities that allow them to engage with Universities. Furthermore, the complexity of these capabilities increases with the complexity of knowledge involved, which also in turn increases the probability of knowledge exchange and mutual learning (Bell 2009). On the other hand, it must also be acknowledged that high level capabilities, especially when coupled with firm size, can lead some actors to have a disproportionate impact on the regional innovation system (Christopherson and Clark 2007). When this happens, rather than aligning University activities with the wider needs of the region the result is a capture of these institutions towards the interests of powerful entities, to the detriment of the wider network of firms and economic agents.

Finally, the translation of knowledge produced in HEIs into innovation outputs is facilitated by the existence of organisations providing intermediation functions. These functions may be performed by a diverse set of organisations that are either internal to the structures of

universities (e.g. technology transfer offices, spin-off incubators), or external agencies (e.g. public research centres) that align with HEIs to facilitate knowledge translation (Wright et al 2008). In some regions, this function may also be performed by targeted financial support (e.g. venture capital) or knowledge-intensive business services (Gunasekara 2006, Pinto et al 2015). The main role of intermediation is to deal with issues of *search*, *incentives* and *coordination*, which emerge from insufficient knowledge among both researchers and firms about each other´s specialisations and potential (Bonaccorsi 2017). Furthermore, the translation of scientific knowledge into commercial applications often involves lengthy and costly processes such as prototyping, testing, or production scale, which researchers may not be prepared or interested in dealing with and that may be too expensive and risky for firms to conduct by themselves (Bonaccorsi 2017, Goddard et al 2012, Howells 2006).

There may, therefore be a need for additional public funding to support specialist organisations that can perform this function of bridging between supply-side and demand-side dimensions of the university-business interaction (Yusef 2008). In the nascent stage of a project, these organisations might also need to coordinate a mix of public and private organisations that can provide funding, political support and if necessary an appropriate regulatory environment (Boucher et al 2003, Olds 2007, Pugh 2017). This is especially relevant in LDRs where this institutional gap within the innovation system is often more pronounced due to limited translational capabilities of universities and/or a failure to effectively articulate a demand for new knowledge on the part of business (Goddard et al 2012, Youtie and Shapira 2008). Demonstrating the value of this function can, however, be a problem for publicly-funded intermediaries because it is primarily manifested in the enhanced innovation capacities of other organisations.

Despite the importance of such services, it is necessary to bear in mind that "intermediary is not a type of actor but rather a role that may be played by a variety of actors of different types" (Flanagan and Uyarra 2016, pp. 179). This is relevant because though one might understand intermediation as an activity which seeks merely to facilitate knowledge exchange between organisations, the actors who play this role are in fact shaping outcomes and their interests might be in contradiction to wider policy goals. For instance, the financialisation of start-up activity is driven by 'intermediaries' seeking rapid valuation of investments, an activity which shapes the type of knowledge which is deemed to be commercially viable (Kedrosky and Stangler 2011). It also contributes to defining University engagement in a

narrow (economistic) fashion, rather than in broader development terms. In this sense intermediation is not a passive activity but may in fact actively contribute to undermine the capacity of Universities to contribute to development in LDRs.

2.2 Practical and normative limits to commercialisation of knowledge

Importantly, while in this paper we put forward a model to understand how Universities contribute to economic development in LDRs, we recognise that the instrumentalisation of universities in the pursuit of these aims poses some important questions (Christopherson and Clark 2007). This is especially the case when their role is narrowly defined around the production of knowledge which can generate economic gains. It is of course dangerous to generalise too much about university models because of the national specificity of higher education systems. In some countries engagement has in fact taken on a much larger significance, as Universities become part of policy coalitions that seek to deliver a wide set of policy outcomes (Raagmaa and Keerberg 2017). However, in the context of the UK this discourse has been overwhelmingly economistic, focusing almost entirely on the university-*business* dimension, even though university researchers are engaged in more capacious and multi-dimensional ways with economy and civil society (Deiaco et al, 2012). Also, this is true even though this type of activity measured by income remains miniscule relative to the income generated by teaching and research, which means that the pervasive discourse about its importance is beyond what the income metric might suggest (Dodgson, 2015; Goddard et al, 2012).

The commercialisation agenda has generated two very different types of criticism from within the academy – from the liberal arts/university engagement perspectives and from the evolutionary economic perspective. A compelling example of the liberal arts critique is Stefan Collini's book, *What Are Universities For?*. Written in defence of the traditional liberal university, it argues that the commercialisation of higher education is corrosive of what universities really ought to stand for. In particular, he argues that the debate about universities in the UK today is dominated by discussions of funding, access and impact, all of which are deemed to be transient political fashions. A different set of criticisms emerges from those scholars which see the University as a civic partner, capable of engaging with multiple stakeholders in building policy coalitions that can contribute to a range of social, cultural or economic aims (Goddard and Vallance 2013).

While the response from evolutionary economics has been less instinctively hostile, it is no less important because it highlights the unintended consequences of the commercialisation of higher education and shows how it can be counter-productive even in its own terms. This is because the "entrepreneurial" model inherent in commercialisation activities creates new tensions between universities and their business partners and threatens the 'Republic of Science' by introducing a more proprietary ethos into the higher education sector. The unintended consequence of this trend - a trend that had its origins in the American Bayh-Dole Act of 1980, which allowed university researchers to retain the intellectual property (IP) rights of their federally-funded research – was perfectly illustrated by a Vice-President of IBM, who suggested that the vigorous assertion of IP rights by universities had gone too far because: "Universities have made life increasingly difficult to do research with them because of all the contractual issues around intellectual property….We would like the universities to open up again" (David and Metcalfe, 2007:38). On the other hand, when universities do not assert their rights it can lead to situations where University-business engagement leads to a transfer of risks in R&D projects from firms to the higher education sector, supported in part or wholly by public funds, while profits continued to be reaped mainly by private firms (Christopherson and Clark 2007). The proposition that universities should become "engines of growth" can therefore become problematic, both from a practical and from a normative sense.

3. Spaces of Novelty: case studies

Wales is one of the poorest places in the UK. Its GVA per head in 2015 was 70% of the UK average, placing it at the bottom of all regions in this country (Pugh 2017). In terms of its innovation potential, Wales had in 2017 the second weakest performance in the UK, according to the EU's regional innovation scoreboard (above Northern Ireland) (EC 2017). Wales does host some important productive facilities in sectors such as steel, electronics or aviation, but very little installed R&D capacity, which means that it could be characterised as a branch-plant economy (Pugh 2017). Regarding the higher education sector, Wales hosts eight Universities, out of which only Cardiff University is part of the Russell Group of intensive research Universities in the UK. Swansea University, Bangor University and Aberystwyth University also have sufficient research capacity to classify as research intensive according to the typology by Kohoutek et al (2017) cited previously in this paper.

The remaining four Universities belong to the second group of vocational universities offering teaching and mostly applied research.

The translation of science into innovation is hampered by a UK context which is geared towards commercial short-termism, and a Welsh context where previous public investments in science and technology were dominated by political concerns rather than an alignment with existent strengths and weaknesses (Morgan 2013). Furthermore, despite having a devolved administration, the capacity of the Welsh government to influence University engagement policies is limited. Each University operates under a Royal Charter which guarantees its independence. Where Welsh Government has influence this is exerted through broader funding arrangements, particularly those taken by the Higher Education Funding Council for Wales (HEFCW). However, autonomy in these matters is constrained by wider UK governance arrangements and by its own decisions not to promote a dedicated Higher Education Innovation Fund (as existed in England and in Scotland). Welsh Government has proved most able to influence University research and innovation activities through its management of subsidy and investment programmes (such as the EU´s Structural Funds) which have funded many of the initiatives referred to in the case studies. Taking these factors into consideration, plus the fact that its a population stands at little more than 3 million people, Wales could be characterised as having some aspects of organisational thickness (especially in the presence of HEIs), but an overall institutional thinness. It is in this context that the two projects discussed here must be considered.

Their relevance is due to their combination of a traditional (in the UK context) engagement approach based on commercialising knowledge, which according to their promoters have the "transformative" potential in and for their regional economies. At the same time, recognising the limitations of the Welsh innovation system, both aim to involve multiple actors learning to collaborate for mutually beneficial ends, akin to what have been called processes of "collaborative creativity" (Isaacson, 2014). Therefore, they have the stated potential of both improving the translational dimension of University business engagement in the region, and of generating new sectors of economic activity with a high level of advanced knowledge. The two projects are: (i) *SPECIFIC*, which aims to design and develop functional coatings that generate, store and release solar energy, enabling buildings to become their own power stations; and (ii) the *Compound Semiconductor Centre* (CSC), which aims to be a centre of excellence for the development and commercialisation of Compound Semiconductor (CS)

technologies and the focal point for the development of a CS cluster in Wales. We will analyse the process through which both projects emerged, by focusing sequentially on the three dimensions discussed (supply-side, demand-side and translation of knowledge) and by providing some comment on their practical and normative implications.

The results discussed here are based on semi-structured interviews with a variety of stakeholders based in Wales. For each project 15 interviews were conducted with the key academics leading it from the University side, with representatives from the major private firms involved in each project, with the project manager for SPECIFIC and the Cardiff University liaison for CSC and with policy makers which accompanied both projects in their various stages. The interview script asked questions about the origin of each project, with the aim of identifying the main organisations and individuals involved and understanding how the relationships between the stakeholders evolved. The script also addressed practical details related to the translational stage, mainly regarding sources of funding, nature and capabilities of organisations involved, timeline and main barriers faced. The researchers took notes during the interviews which were then organised according to the three dimensions discussed in order to allow for a comparison of results.

3.1 The University as supplier of knowledge

"Buildings as power stations" is the goal of SPECIFIC (Sustainable Product Engineering Centre for Innovative Functional Industrial Coatings), an academic and industrial consortium led by Swansea University, with the firm Tata Steel as the main industrial partner. Located in Baglan Bay in the municipality of Neath Port Talbot, SPECIFIC was created in 2011 to develop and commercialise a portfolio of functional, glass and steel 'smart coatings' that deliver clean renewable energy from the built environment. They do so by capturing, storing and releasing energy at the point of use – enabling both new and existing buildings to become their own power stations.

This project emerged out of the materials research centre in the Swansea University School of Engineering. Its head, Prof. Wilshire, was responsible for the initial links with the Steel Company of Wales (SCW) in Port Talbot (now Tata Steel) in the late 1980s, through teaching and research collaboration. Materials science at Swansea University has benefited for many years from UK research council investment and recently by the creation of SPECIFIC, a £20m five-year project and one of just seven Innovation and Knowledge Centres (IKCs) in

the UK funded by the EPSRC (Engineering and Physical Sciences Research Council). It also received additional support from Innovate UK and from the Welsh Government. According to the project manager, this has led Swansea University, and the team that was allocated to the SPECIFIC project, as being recognised as operating at the cutting edge of technological development in the area of functional coatings. Their capacity to establish strategic partnerships with high quality organisations, such as the universities of Bath, Imperial College, and Sheffield and with industry leaders such as BASF, NSG (Pilkington), Tata Steel and others, provide some evidence that they may have in fact achieved such recognition.

The history of the engagement between Swansea University and what is today Tata Steel seems to suggest that the University played predominantly a developmental role. This is because it shows a long-term alignment of research strengths with the local economic structure, incorporating a series of activities including human capital provision and research collaboration. In turn, the emergence of SPECIFIC, created under the guidelines of the UK government, which as we have seen is predominantly interested commercialisation activities, seems to shift this engagement towards the idea of the entrepreneurial University. One consequence of this is that intellectual property rights issues, and other conflicts regarding the future development of commercial technology, have now become a core concern within the project, as will be discussed later.

The Compound Semiconductor Centre (CSC) is a more recent project, having been launched in 2015 with two aims in mind: first, to become a centre of excellence for the development and commercialisation of Compound Semiconductor (CS) technologies and, second, to become the focal point for the development of a new CS cluster centred in South Wales. Similar to SPECIFIC, the CSC is the culmination of a long-term collaboration that began in 1988, when the firm IQE opened its plant in Cardiff to access the semiconductor expertise and facilities of Cardiff University. This means that in this case the location decision for the firm was the direct result of pre-existing University capabilities. The CSC itself was funded by a multiplicity of sources, including £14 million from Cardiff University and £20 million in gifted capital assets from IQE. Due to its involvement in the CSC, the University has also been able to secure an additional £17.3 million capital investment from the UK Research Partnership Infrastructure Fund, which is administered by the Higher Education Funding Council for England (HEFCE), for a new research facility at Cardiff University (the Institute for Compound Semiconductors); and £12 million from the Welsh Government to support

translational research. The ICS is also being supported by Sir Cymru, the talent scheme designed to attract star scientists to Wales.

The creation of the CSC was due to a very practical issue: the lack of a physical infrastructure that could support innovative multi-disciplinary research, large scale industrial collaboration and technology translation. Though commercialisation activities also fall within its remit, the rationale for the creation of the CSC was broader in comparison to SPECIFC, where the aim was specifically to test and upscale an existing technology. In addition to these physical constraints, the University also faced internal obstacles from both its management and academic sides, due to work cultures that are not favourable to this type of activity. The former was concerned about the financial risks of the venture, while the academics not involved in the CS field were concerned about the opportunity costs of investing so much in engineering and physics. The University's governing body (University Council) eventually decided to support the proposal largely because of strong internal support from the University Executive Board together with strong external support from the Welsh Government and HEFCE. This decision was also influenced by the wider vision for translational research at Cardiff University brought by a new Vice Chancellor, who arrived in Cardiff in 2012 committed to the idea of a more engaged university.

The history of semiconductor research at Cardiff University suggests a more entrepreneurial role for the University from the start. First of all, research capacity in this area was created previous to the installation of IQE in the city. It could in theory have remained as a purely academic pursuit, had this firm not decided to locate there. Also, the CSC has a broad remit including research and eventually commercialisation, and as such points towards the University taking a lead role in capitalising on its internal knowledge. This is true even if, as we shall see, the creation of this centre happened in direct collaboration with an external partner. Finally, the fact that IQE is a relatively small firm in a region that is not known for its expertise in this area, also suggests that rather than aligning current interests with the pre-existing economic structure the goal is to leverage expertise in this area into a potential future economic specialisation.

In both cases, the development of a new technology with commercial potential is the product of a rather serendipitous process, involving individual research interests, institutional strategies, and the capacity to capture funding streams, which encourage and facilitate a series of development steps that these Universities would have struggled to implement by

themselves. Importantly, they show how even when there is a narrow concern with commercial gains, opportunities to generate such gains may be dependent on long-term processes. This suggests that short-term strategies aimed at rapidly generating value from advanced knowledge are likely to be self-defeating, unless Universities have already received sufficient funding over long-term periods to reach a stage when they are prepared to engage in such processes.

3.2 Capabilities in the private sector

Regarding absorptive capacity in the private sector, this issue is guaranteed for SPECIFIC by the central role played by Tata Steel, a multinational headquartered in India with R&D facilities in Swansea. However, despite their presence and their centrality to this long-term relationship, their nature as a multi-location firm has put some strain on the project. First, this is because the commercialisation stage is almost wholly dependent on Tata Steel being able and willing to invest in manufacturing capacity, a path it seems reluctant to take. Tata Steel sees itself as a traditional steel company and the SPECIFIC project would take it out of its core competencies, which suggests a strong path dependency on traditional product lines. Second, the fact that the IP of the SPECIFIC project is wholly owned by Swansea University has made Tata reluctant to commit more resources to a technology that it does not control. Thirdly, Tata has showed an interest in taking the technology to Tata HQ in Mumbai, which operates a solar division, and where R&D costs are one-fifth of the costs in the UK. The managers for SPECIFC argued that existing expertise (the key technologist, Dave Worsley, lives in Swansea) and intellectual property rights (IPR) would protect them against such a decision, though it still highlights the potential barriers to the full realisation of SPECIFIC's wider development goals.

The project managers have also sought to address these conflicts by stimulating collaboration along the wider value chain, which incorporates a total of 20 industrial partners. This allows them to have access to specialised knowledge and to have early feedback on whatever products they develop. It also helps create a balance between large and small firms, to take advantage of their different strengths. Large partners are valued due to their resources, their global outlook and their longer time horizons, whereas small firms can respond more quickly and are more willing to exploit a small opportunity.

In the CSC example, the main business partner is IQE, which despite its relatively small size, is the global leader in the manufacture of compound semiconductor wafers, with 11 locations worldwide, including five in the US, one in Singapore and one in Taiwan. Being a small company of some 450 employees worldwide (116 of whom are based in Cardiff), its main interest in this project is that it would help to spread the burden of R&D and afford new opportunities to commercialise the research of the CSC at Cardiff University. As part of its future growth strategy, the company plans to consolidate production in fewer but larger plants and the support of a CS cluster in South Wales would ensure that Cardiff remained one of those consolidated production sites - the implication being that it might not be a viable location if the CSC project failed to materialise. For that reason, the firm played a big part in developing the idea of a CS cluster in Cardiff, on the basis that it would be important not only for the region but also nationally and globally. Speaking of the UK, the CEO of IQE said:

> "We frequently fail to take the steps needed to commercialise R&D activities through to innovation and manufacturing. This is the problem that IQE's partnership with Cardiff University seeks to overcome. This partnership seeks to surpass traditional private sector funding of bespoke academic research. Through the CSC, Cardiff University will now have a clear and effective route to commercialise world class R&D originating from the Institute, and will be able to attract significant corporate and other R&D funding. As a result, IQE will be able to take the technologies developed at ICS directly into mass production" (Nelson, 2015).

In both projects, local demand was not therefore a primary concern. However, both SPECIFIC and CSC are expected to deliver wider development goals for the region and the UK rather than only for the primary industrial partners. This justifies the significant amounts of investment from Welsh and UK authorities. Considering the issues already raised by Tata Steel, and the fact that up to now there is only one major semiconductor firm in Cardiff, there are questions about whether there will be enough demand from a wider variety of economic agents in the future. This would be a necessary precondition for these projects to have a truly transformative role on the region's economy.

3.3 From knowledge to innovation

As well as the developmental challenge, SPECIFIC faces the additional challenge of manufacturing the functionally coated building materials at scale. To meet this challenge, SPECIFIC has set up a production facility alongside the IKC to enable the portfolio of product concepts to be manufactured and tested in a range of different environments. Ten potential products have already been identified, working in collaboration with the construction industry, and progressed to the proof of concept stage. Each innovation is demonstrated to potential customers, designers, architects, partners, planning officers, policy-makers and the feedback received is used to identify the technologies which need further development.

Although collaboration has, according to interviews with the project manager and the other partners, worked better than expected to date - due to a combination of good working relationships and physical proximity – it has also spawned a number of difficult strategic issues that will need to be resolved if the project is to fully realise its commercialisation goals. Aside from the IPR question, the geographical location and the scale of the SPECIFIC project have also been problematic. First and foremost was the fact that their geographical location (in Baglan Bay, Swansea) was not the ideal location for recruiting and retaining talent. Second, the UK as a whole is not a great location for the kind of translational research that is the core of the SPECIFIC project (Jones 2016). Basic science is seen to be celebrated, but translational research is not. In fact, two of the project partners, Oxford University and Imperial College London, were interested in this project exactly because they wanted to learn about how to engage with industry and to learn how to bring costs down in a real industrial setting.

Fortunately for the project, SPECIFIC has benefited from its resonance with both political and regulatory goals for the UK as a whole, as seen in the 2009 Renewable Energy Directive, which tasks the country with achieving 15% of its energy consumption from renewable sources by 2020, compared with just 3% in 2009. This project is highly relevant because, according to the Carbon Trust (2009), around 40% of all CO2 emissions in the UK come from the demand for heat and light in the built environment, making it a sector which is both part of the problem and of potential solutions to the problem of climate change. At the regional level, the Welsh Government (WG) had also played a very significant role. Although its £2m contribution was a small part of the original £20m, it was leveraged for further investment at subsequent steps. Having built up a track record the project was then able to

attract ERDF/ESF money to fund the pilot line and equip it with state-of-the-art kit. WG had also helped to fund the involvement of the Imperial College professor with its Ser Cymru scheme designed to attract "star" scientists to Wales (the same programme used to attract a star scientist to the semiconductor centre).

With regard to the translation of knowledge produced in the CSC into innovation outputs, a commercial for-profit entity has been created which is equally owned by the University and IQE, a division of control that is reflected in an equal number of seats on the Board of Directors. Because the CSC is a highly novel undertaking, it has faced two major challenges. The first was the need to assemble the funding package from multiple sources. Although the CSC project may appear to be a "regional" innovation project, it might not have materialised had it not resonated with UK-wide bodies like the Department for Business, Innovation and Skills (BIS), HEFCE, and Engineering and Physical Sciences Research Council (EPSRC). Furthermore, the joint venture with IQE enabled Cardiff University to secure £17.3 million of capital funding from HEFCE's UK Research Partnership Investment Fund (RPIF). The application was approved in March 2015 on the basis that IQE will commit £34.7 million to the CSC over the first five years. The University's engagement with the CSC has therefore generated total investment in excess of £33 million for the Innovation System on the Maindy Park site (i.e. £17.3 million from RPIF; £12 million from Welsh Government, plus a further £4 million from WEFO).

The second major challenge was the need to align the interests of IQE, the University and the Welsh Government. Although the Welsh Government was supportive from the outset, it was concerned that it might fall foul of EU state aid rules if it was seen to be dispensing financial support directly to IQE. For that reason, it initially preferred to direct funds to the project via the University side of the partnership. However, an independent evaluation commissioned by WG concluded that, notwithstanding the risks, it was a worthwhile project because the potential benefits outweighed the costs (Huggins et al 2014). Furthermore, the CSC concept was closely aligned the *Welsh Innovation Strategy*, which aims, among other things, to develop financial products that can bridge the gap between research and new product development, and to support universities and businesses to develop a small number of centres of excellence in areas of comparative strength and market opportunity (IQE, 2014). Finally, the WG was attracted by the job creation potential of a project that promised to deliver "Europe's Fifth Semiconductor Technology Cluster" (alongside the other clusters in

Grenoble, Eindhoven, Leuven and Dresden), where up to 5,000 new jobs could be created (Kelsey, 2015).

3.4 Practical and normative implications

Both projects raise important practical and normative questions. Regarding the former, the main question is whether they can deliver on their wider developmental goals. Even if both projects are successful in delivering their specific outputs, it is still highly uncertain if they can generate a new economic path for the region, capable of creating thousands of new jobs, a number of new firms, and future demand for more University knowledge. On a systemic level, it is unclear if they can contribute to increase institutional thickness, beyond the agents that are directly involved in them. In the case of SPECIFIC these issues were highlighted when discussing the reluctance of the main industrial partner, in terms of their interest in continuing to engage with the project, or in terms of their preferred location for production. Also, after announcing that they were going to sell the site last year, Tata Steel has now announced a merger of its European operations with ThyssenKrupp (Monaghan 2017), which will lead to cost savings in several areas including R&D. At this stage it is unclear what the effects of this merger will be on the Swansea location, but it demonstrates the difficulties of engaging with multinationals whose location decisions and strategic partnerships can significantly shape the fate of host regions. For CSC, the main danger is the inability to attract other significant private sector investments which would mean the failure to generate a new cluster. Even if it becomes a successful research centre, its valuable intellectual outputs may merely be bought and appropriated by firms operating elsewhere. Also, since IQE is the major industrial partner, if it decided in the future to close its Cardiff location, this would undermine the whole project because the University is wholly dependent on this one company. If these risks materialised, questions would be raised about the opportunity costs of having the Welsh Government and other public funds mobilised for a high-risk venture in the context of such asymmetrical power relationships.

The normative issues are equally important. The perspective from IQE on the creation of the CSC and the reasons it presented for it were illuminating, since the company explicitly said that without the CSC "it is unlikely IQE would retain its manufacturing operation in Wales as there are identical production tools in Taiwan...resulting in the loss of almost 100 highly skilled jobs" (IQE, 2014). This raises questions about public funds being used to support the competitiveness of private companies, especially when not all companies will have access to

the same level of political support. Though this issue is not as relevant in the case of SPECIFIC, because functional coatings are not part of Tata's core specialisation, both projects also raise questions about who is responsible for assuming the burden of high-risk technological development projects. As Christopherson and Clark (2007) showed in the case of the photonics industry in the US, there is a strong possibility that firms use engagement with HEIs as a means of socialising what used to be private costs, while continuing to reap most of the profits when innovation outputs are successful. Mazzucato (2013) also cautioned against such risks, when she argued that governments, who have been so important in funding and guiding the development of new technologies, should ensure that they share some of the profits when firms use these technologies for successful innovations.

The practical and normative implications of both projects suggest that the drive behind a narrow commercialisation agenda might be misguided, if it fails to generate any major developmental outcomes, while functioning as a tool to support the agendas of specific companies with good access to policy makers.

4. Conclusions and Implications

Under certain conditions, Universities have the potential to play a catalytic role in regional development through their engagement activities, but this path is far from straightforward as our case studies demonstrate. This is particularly the case when engagement is understood narrowly as commercialisation rather than participation in stakeholder networks that can mobilise a wide range of resources (Kohoutek et al 2017). In both cases, the existence of a high-quality research department was an important precondition**.** Another important precondition was the close physical proximity of internationally competitive firms in their respective areas of business. A third precondition was the presence of key individuals animating these projects. Finally, the combination of multiple funding sources and the attraction of outside partners provided leverage to bring these projects to fruition. Nonetheless, although these elements are important, they are not sufficient to explain the outcomes and they cannot guarantee the ultimate success (measured in terms of job creation, for instance) of the projects. A significant number of universities across the UK and beyond can boast the presence of excellent research centres, individually engaged academics and ambitious research strategies, without it necessarily translating into promising innovation

projects (Bonaccorsi 2017). This paper has used a three-part framework of supply-side, demand-side, and translational dimensions of university-business interactions to unpack the multifaceted reasons why, even with the presence of favourable preconditions, commercialisation projects may not generate significant economic development impacts in the context of LDRs. Each of these dimensions presents unique challenges.

First, from the perspective of the HEI, we argue that a narrow understanding of engagement can work against the University performing a developmental role, which is based on the medium to long-term alignment of university capabilities with the needs of local actors (Gunasekara 2006). The pressure to deliver short-term gains may instead lead the University to invest in areas of knowledge that are believed to have greater potential for commercialisation, but that are not relevant to the needs of local actors (Bonnacorsi 2016), leading to a policy that is self-defeating on its own terms i.e. greater investment for less or similar levels of engagement (David and Metcalfe, 2007). This is not necessarily the fault of the HEI, since universities operate in an environment strongly shaped by national regulation and international trends that at least in some contexts pushes them towards this entrepreneurial role (Brown 2016, Collini 2012). Their success in this arena is therefore dependent on the capacity to navigate these multiple and potentially contradictory demands, by fulfilling the requisites of, among others, governments, funding agencies, or firms while trying to make all these demands coalesce around specific innovation ideas.

Second, such innovation projects are only possible with the existence of valorisation agents like firms, which can turn the knowledge produced into a viable commercial good or service. Though universities can seek to create firms in contexts where they do not exist, through science parks or incubators for instance, their success so far has been limited outside of a few core locations (Bonaccorsi 2017, Degroof and Roberts 2004). Therefore the existence of demand in LDRs is often dependent on the embeddedness of multinational corporations (MNC) present in the region, which in turn is the result of engagement strategies decided at the headquarter level. Regional authorities may seek to change these strategies by providing a unique set of competencies and a stable institutional environment, which can convince the firm to extend its networks to local actors (Iammarino and McCann 2013). This is a medium to long-term strategy, which again points towards the importance of a developmental approach to the management of universities, but that even then will need to take into account that the internal logic of the MNC may not align with the interests of regional authorities.

When demand comes from firms headquartered in the region, the main danger is that due to economic decline or low growth this organisation may be in a position to bargain for public support, which poses questions about the opportunity costs and normative implications of supporting specific firms (Christopherson and Clark 2007).

Finally, conventional models of the triple helix are unlikely to be applicable in the context of LDRs, both due to insufficiencies within organisations and the fragmentation of networks between them (Marques and Morgan, 2018). In the cases discussed in this paper, the Welsh Government has in fact played an important role, aided by flows of knowledge, funding and business or political support that cut across organisational and territorial boundaries, and public-private-third sector divisions. These were however outlier projects in the region, where the public sector has often lacked the capacity to engage in what are extremely complex processes of alignment between divergent interests (Huggins and Kitagawa 2012, Morgan 2013). The lack of capabilities in the public sector, together with the problems already identified in the supply and demand of knowledge, pose important questions about the true impact of HEIs on regional economies, outside of a medium to long-term (and therefore risky) strategy. Furthermore, although these case studies demonstrate that universities can play a catalytic role in crafting novel technological projects in LDRs, the final outcomes in terms of regional economic development are still uncertain. In other words, despite the very real achievements of the universities in Cardiff and Swansea, these complex knowledge-based projects have some way to go before such "spaces of novelty" are valorised in local economic development terms, a *commercial* process that is beyond the ambit of the academy.

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