GREATER MANCHESTER INDEPENDENT PROSPERITY REVIEW

UNDERSTANDING INNOVATION AND INNOVATION ECOSYSTEMS

A technical report for the research on
Innovation & Global Competitiveness

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Authors: Chiara Marzocchi, Elvira Uyarra and Kieron Flanagan, The Manchester Institute of Innovation Research (MIOIR)

The Manchester Institute of Innovation Research (MIOIR) is a centre of excellence in the field of innovation studies, building on a 50-year tradition of innovation and science studies in Manchester. The Institute comprises of a group of internationally renowned scholars and experts, and supports a broad expertise across a range of academic disciplines. With more than 50 full members, approximately 50 PhD researchers, and a range of associated academics, they are Europe's largest - and one of the world's leading - research centres in our field. They are at the heart of innovation-related research and also form one of the largest components of the University of Manchester Research Institutes (UMRI).

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The University of Manchester
Alliance Manchester Business School

The Greater Manchester Independent Prosperity Review was commissioned to provide a detailed and rigorous assessment of the current state, and future potential, of Greater Manchester's economy. Ten years on from the path-breaking Manchester Independent Economic Review, it provides a fresh understanding of what needs to be done to improve productivity and drive prosperity across the city region.

Independent of local and national government, the Prosperity Review was carried out under the leadership of a Panel of six experts:

Professor Diane Coyle
Bennett Professor of Public Policy, University of Cambridge, and
Chair of the Greater Manchester Independent Prosperity Review

Stephanie Flanders
Head of Bloomberg Economics

Professor Ed Glaeser
Fred and Eleanor Glimp Professor of Economics, Harvard University

Professor Mariana Mazzucato
Professor in the Economics of Innovation & Public Value and Director of UCL Institute for Innovation and Public Purpose

Professor Henry Overman
Professor of Economic Geography, London School of Economics, and Director of the What Works Centre for Local Economic Growth

Darra Singh
Government and Public Sector Lead at Ernst and Young (EY)

The Panel commissioned studies in four areas, providing a thorough and cutting edge analysis of key economic issues affecting the city region:

- Analysis of productivity, taking a deep-dive into labour productivity performance across Greater Manchester (GM), including a granular analysis of the 'long tail' of low-productivity firms and low pay;
- Analysis of education and skills transitions, reviewing the role of the entire education and skills system and how individuals pass through key transitions;
- Exploration of the city region's innovation ecosystems, national and international supply chains and trade linkages; and sources of global competitiveness, building on the 2016 Science and Innovation Audit; and
- Work to review the infrastructure needs of Greater Manchester for raising productivity, including the potential for new approaches to unlock additional investment.

A call for evidence and international comparative analysis, developed in collaboration with the Organisation for European Cooperation and Development (OECD) and European Commission, also supported this work.

All of the Greater Manchester Independent Prosperity Review outputs are available to download at **www.gmprosperityreview.co.uk**.

This technical report is one of a suite of Greater Manchester Independent Prosperity Review Background Reports.

1. Introduction and Scope

Understanding innovation in GM

In current policy debates notions of growth, productivity and innovation are often bundled together. We know that innovations are a source of productivity growth directly and indirectly (e.g. when firms that are more productive due to innovation displace less productive rivals, where those rivals are motivated to improve their own productivity in order to compete, or through the wider diffusion and adoption of an innovation across a sector or economy). However, a focus on productivity should not be at the expense of the broader contributions of innovation to the processes of wealth production and distribution and ultimately social welfare.

This report includes a deeper understanding of: innovation diffusion, adoption, trajectories; innovation in services and creative industries; skills relatedness and; knowledge complexity; the innovation ecosystem and place-based innovation. The report has been compiled to represent the current consensus (where it exists) on the topics covered drawing on our expertise as active contributors to research in these areas.

2. Innovation: Novelty, Diffusion and Adoption

According to national accounts /standardised OECD definition (OECD 2018), "[a]n innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" (Oslo Manual, pp 20). This definition, whilst identifying relevant dimensions of innovation (product and process) does not address the activities, interactions and places through which, and where, innovation might occur. Innovation is treated as a discrete process, with easily identifiable and quantifiable boundaries. This is flawed in two ways: First, it identifies innovation with business sector dynamics, neglecting the many other spaces where innovation can occur such as public sector and user interactions as well as networks, platforms and ecosystems. Second, it defines innovation exclusively by degree of novelty.

Thus, in the broadly accepted definition innovation is associated with the degree of novelty in the process of knowledge creation. However**, in order to understand the uneven distribution of innovation across places, systems, actors and organisations it is also important to consider patterns and dynamics of diffusion and adoption of innovation**. Diffusion represents the rate at which societies embrace change (adopt innovation) by replacing old technologies and practices with new ones (Rogers, 1962). To a great extent, **diffusion defines the societal impact of innovation** and indeed can be thought of as an **intrinsic part of the innovation process itself that generates learning, imitation and feedback effects** (Hall, 2003). In this perspective, the rate of diffusion of innovation is relevant because it is indicative of the capacity of the actors to react and respond to innovation and the different rates/timing they use. Naturally, **processes of diffusion and adoption are typically not smooth but context-specific (market/technology/ organisation) and affected by multiple uncertainties**. There are numerous risks associated with shifting to a new practice or technology (see Stoneman, 2001). For instance, cost barriers emerging from the required complementary investments necessary to adopt a new innovation including both sunk costs and costs associated with training and upskilling (see Mowery and Rosenberg, 1998). Diffusion can also be affected by factors such as network and lock-in effects (see David, 1985; Katz and Shapiro, 1985) that make abandoning established paths and practices risky, due to a combination of costs and social norms that may be hard to tackle and change.

If we measure diffusion of an innovation by time of adoption by members of a population of potential adopters, then the diffusion typically presents an S-shaped distribution. The implication is that adoption is at first a slow process that becomes epidemic once the population understand the value of the innovation at hand. Once the full potential user-market is saturated, the rate of adoption of innovation slows down again. Noticeably, returns from adopting innovation across these stages are different. Those that master the process first (first-movers) build an advantage and reap higher rewards associated to appropriating the innovation first while developing a capacity to extend the original knowledge and exploit its value both directly and indirectly in processes of further incremental innovation.

Today, however, this classic conceptualisation of diffusion is challenged by increasing levels of complexity. For instance, **many innovations are embedded in complementary services and platforms and their value chains are spread across geographies** (e.g. mobile phones and electric cars). Moreover, **consumers' perceptions and practices of social adoption increasingly drive the rate and success of innovation diffusion** (e.g.: organic food).

Thus, innovation can no longer be considered exclusively as the novel exploitation of inventions into commercially valuable product and services. **To become a valuable place-based asset with societal impact, innovation needs to be understood alongside the challenges linked to its processes of adoption and diffusion. This implies that an important goal of innovation policy should be to help upgrade those capabilities of innovation users (in business and society) that may facilitate the absorption of innovation in an organisation and help bind it to a place**.

Capabilities are "a special type of resource – specifically are organisationally embedded and non-transferable resources whose purpose is to improve the productivity of other resources possessed by the firm" (Makadok, 2001, p.389). Capabilities are tools that transform efficiently available resources into greater economic returns. They represent the learning capacity in organisations and can be acquired by investing in human resources. However, they are not a static asset. On the contrary, to be able to tackle challenges of obsolescence and to support absorption of innovation, capabilities must evolve and anticipate market changes via practices of learning by-doing, by-using, and by-interacting.

Effectively, capabilities increase an organisation's capacity to develop internal knowledge and recognise, evaluate and internalise externally generated knowledge. The accumulation of capabilities within an organisation drives the building of absorptive capacity, e.g. the mechanisms enabling exploration of new or improved goods, services, processes, and their commercial exploitation (Cohen and Levinthal, 1990).

As innovation dynamics are increasingly linked to knowledge-intensive activities, absorptive capacity is a framework for dynamic capabilities to develop a firm's knowledge base and increment its innovation potential (Zahra and George, 2002). Notably, capabilities and absorptive capacity are nurtured by both external and internal factors. The underlying dynamic to support this process is driven by the capacity to find a balance between internal investments and external engagement. For instance, building social networks and integrating them within the organisation (Todorova and Durisin, 2007) is paramount for the continuous improvement of organisational capabilities and absorptive capacity. In this sense, **place-based dynamics/provisions can anchor an organisation's ability to renew itself and strengthen its competitive advantage**. Failure to develop such dynamics can result in organisational inertia characterised by core rigidities, path dependency and ultimately the incapacity to develop and absorb new innovation (lock-in).

Recent systematic reviews of the literature have suggested that substantial innovation taking place in companies, societies and institutional organisations tends to be neglected. In particular, disproportionate attention is devoted to radical and disruptive forms of product innovation, while softer innovations involving incremental (new-to-the-company) changes in the production process, or less tangible innovation involving services and administrative practices are often neglected (Keupp et al., 2012).

As a result, the extent of innovation in the service economy has been extensively re-evaluated, resulting in a renewed focus on things like design processes, information technologies, service customization, and knowledge sourced from customers, procedures and organizational methods. Today, it is acknowledged that many productivity-enhancing innovation investments by services firms involve technology acquisition, integration, or modification rather than in-house production through R&D (Miles, 2005). It is becoming clear that many of these investments are crucial and will be driving the productivity challenge for the years to come, given the increasing relative importance of intangible assets in the economy (Haskel and Westlake 2017).

Administrative innovation is another form of neglected innovation, particularly with regard to innovation adoption at the local government level. Naturally, public-sector decisions to innovate are subject to a series of pressures (including learning from other experiences, public pressure, or local demand). However, evidence suggests that, at the local level, governments successfully innovate their practices for service delivery and procedural support for users where they are more responsive to user demand, e.g. where they show capacity to learn and integrate professional associations and central government views in local strategies (Walker et al.2011). These issues of services innovation, public-sector innovation and 'hidden innovation' more generally will be discussed in more detail below.

The implication is that innovation is not exclusively about R&D spending to fund new product or processes, goods or services. It is a process and as such it requires sustained and articulated investments in strategies that facilitate the absorption of external innovation both from places and organisations. This in turn implies the necessity to develop policies that tackle real or perceived costs and risks associated with innovation adoption, for instance around reducing the scouting costs for innovation, tackling the perception of risk associated with change and improving the incentives to take risks, and improving the quality and relevance of intermediation/brokerage for innovation.

3. Innovation sources and mechanisms

Key to innovation is the application of useful, useable knowledge to social and commercial aims. The success of this process can occur via different patterns. One pattern might involve a search for new knowledge that involves a cumulative process (in R&D for instance) internal to the organisation. However, as already noted, most knowledge held by organisations originates from external sources and is absorbed and adapted internally (Dosi 1988). The distinction between internal and external sources of knowledge for innovation becomes fuzzier as knowledge becomes increasingly complex and spans global value chains. Moreover, companies require a combination of internal resources (capabilities, R&D) to develop new knowledge but crucially also to be able to search for the external sources necessary to complement their organisational provisions (Kogut and Zander 1992, Roper and Love 2018).

Managing the innovation process requires a perspective on the sources of knowledge needed, who produces it, and under which framework conditions such knowledge best flows across different organisations, applications and places. This modern, evidence-based understanding stands in sharp contrast with earlier (but persistent) views of innovation as a straightforwardly linear process in which scientific discoveries are taken up and commercialised into successful innovations. This earlier view is associated with science-push policies (i.e. public subsidy of discovery science with perhaps some attention to technology transfer). Science-push views see technological progress as linear and cumulative, with the rate of innovation proportional to the rate of scientific discovery, assuming efficient technology transfer mechanisms. It was typically argued that markets will fail to deliver the socially optimal level of investment in research, especially perhaps in discovery science (Nelson, 1959; Arrow, 1962) – though early proponents such as Bush (1945) did in fact emphasise the role of science funding in the training of a stock of skilled researchers as well as in initiating a linear process of innovation. At the same time, linear thinking encouraged the growth of corporate R&D and in-house innovation activities (Chandler, 1977). Since then, a variety of empirical studies have convincingly refuted the notion of a direct linear link between science and innovation, showing that **successful innovation rests on the capacity to source a plurality of actors in the process and embed them in a regional context** (Gertler et al., 2000).

The capacity to embed innovation sources within a regional economy is relevant because the process of innovation is indeed not linear but characterised by complex feedback effects, not only within an innovating organisation (Kline and Rosenberg, 1986) but also via the interaction with actors outside. Indeed, knowledge acquisition occurs by means of socialization, externalization, combination, and internalization between companies that iteratively transform know-how (or tacit knowledge) into explicit knowledge (knowing-that) embodied in different forms of innovation (Nonaka, 1994). This is a process of knowledge recombination: the greater the number of complementary sources of knowledge inside and outside the company, the higher the chances of innovation success (Leiponen and Helfat, 2010). In order to increase productivity, companies need to combine internal and external factors in a balancing process between organisational and environmental characteristics (Rothaermel and Alexandre 2008). **Beyond R&D, training and skills acquisition contribute to innovation by generating variety in the knowledge base available to the firm** (Asheim and Coenen, 2005; Leiponen, 2005). In sourcing new knowledge **firms also draw on specialist consultants, outsource R&D to universities or specialized firms, or develop cooperative agreements along their value chain with suppliers, customers and even competitors** (von Hippel, 1996; Veugelers and Cassiman, 1999).

Thus, as well as investments in deepening the knowledge pool internal to the company, innovation requires investments in social capital and networks (Powell, Koput and Smith- Doerr, 1996) to extend the breadth of access to competencies outside the company (Laursen and Salter, 2006). This, in turn, means that **innovation is a distributed process** (Lundvall, 1992) that requires different types of cooperation and interactions in order to succeed. Forms of cooperation include strategic alliances, networks and more or less formal collaborative agreements between companies. Collaboration is relevant not only because it allows companies to access knowledge that they do not possess but also because it allows them to share the risks associated to the investments required in the innovation process.

In particular, **the supply chain is a key locus for learning and knowledge transfer**, and surveys of innovators consistently show customers and suppliers to be the most important sources of knowledge for innovation. **Involving users and customers in the innovation**

process reduces the chances of market failure after the introduction of a new product. Users provide technical know-how, help assessing quality and price standards and provide feedback to the company while testing the product (Shaw, 1994). The rewards of this involvement are higher the higher is the level of complexity or novelty of the product. Collaborating with suppliers provide similar advantages. However, the most relevant ones involve the reduction of the transaction costs associated to the collaboration, e.g. the capacity to balance requirement of short-term investments with long term competitive advantage. The main advantage of cooperating with suppliers resides in the chance to outsource activities at the company level while complementing internal R&D efforts.

Outside the value chain, cooperation might occur with universities and other research organisations, consultants or competitors. While the motivations for cooperating with some of these actors is similar to those that incentivise cooperation within the value chain, such as complementarities in the innovation process, collaboration with direct competitors brings higher risks (Arranz and Arroyabe, 2008). It is relevant to notice that rather than pure cooperation, collaboration with competitors can be viewed as a hybrid form of coopetition (Brandenburger and Nalebuff, 1996) where competing firms cooperate to create value and a bigger market for each participant but later compete for the value they originally jointly contributed to create.

Mechanisms of coopetition pose challenges as they might harbour intentions to collude under the umbrella of synergies for R&D. However, collaboration strategies with competitors have been shown to arise also in relation to a variety of other factors (Tether, 2002). For instance, industry collaborations can serve to establish common standards, particularly when the degree of novelty is high, and the degree of replicability is a risk. Moreover, setting common standards across companies that collaborate can eliminate resistance to change from a consumer perspective and avoid issues of path dependency and lock-in. Collaboration among competitors is also common where companies face a shared problem and, hence, are incentivised to bring together their distinct capabilities to find a common solution that would benefit each party. Finally, collaboration between competitors can be established across firm-specific knowledge domains where either company possesses a strategic advantage.

As previously pointed out, the contextual understanding of the innovation process has shifted from a linear view of scientific and technological knowledge accumulation as a sufficient condition to stimulate innovation in the society at large to a more articulated view. **Innovation is a distributed process that cannot be managed by a company internally and in isolation, but that necessitates the use of external knowledge sources that interact with the organisational capabilities**. This is directly linked to the degree of complexity embedded in innovation, both in terms of the required knowledge domains and market outreach.

The implication is that innovation is a distributed process that cannot be managed by a company in isolation. Companies need external knowledge sources that interact with their internal organisational capabilities. Therefore, as well as investments in deepening the knowledge pool internal to the company, innovation requires investments in social capital and networks. Successful innovation rests on the capacity to source a plurality of actors (users, suppliers, specialist consultants/firms, universities, and even competitors) in the process and embed them in the regional context. Beyond R&D, training and skills acquisition generate variety in the knowledge base available to the firm (and are likely to be more important than R&D in some sectors such as Services).

4. Knowledge exchange: Universities, skills and the spill-over effect on local communities

While universities are often the least frequently used knowledge source compared to partners in the supply chain, such as suppliers or customers, they have been found to be of significant importance for certain industries and contributing to more radical types of innovation. Salter and Martin (2001) identify six ways in which universities influence innovation and technological change: **increasing the stock of knowledge; training skilled graduates; creating new instrumentation and methodologies; facilitating the formation of problem-solving networks; increasing the capacity for problem solving; and creating new firms**. This identifies universities' contribution to local economic growth with both direct mechanisms for knowledge creation (research, training, entrepreneurship), but also with the residual effect of having universities as hubs of knowledge creation (facilitating the formation of problem-solving networks; increasing the capacity for problem solving) (Youtie and Shapira, 2008; Uyarra, 2010). This residual capacity is often defined as a spillover: an externality generated by universities that are appropriable by other actors (Breschi and Lissoni, 2001). The externalities related to knowledge for innovation are generated by the activities undertaken by universities while promoting their missions of research, teaching and economic development.

Firstly, Higher Education Institutions (HEIs) dedicate direct efforts to commercial exploitation of academic research. Accordingly, there are a number of dedicated training and transfer infrastructures such as Technology Transfer Offices (TTOs), Science Parks and Incubators that can relevantly play a role in the city-region landscape. This direct effort towards knowledge transfer from universities typically involves knowledge commercialisation practices (e.g. licensing a patent, creating a spin-off or technology-transfer offices as well as other incubator structures). In addition to these, universities exchange knowledge with others via consultancy, contract research, joint research, and the use of facilities. In these instances, the university and the innovator co-create knowledge and the innovator uses a share of that co-created knowledge as an innovation input, for instance via contract research or consultancy.

Secondly, HEIs have historically been regarded as prime source of training for skilled human capital via the education of students or life-long learning activities and as such they have a direct impact on productivity and labour markets. The skills embedded in university curricula support the capacity of graduates to become key assets in their place of employment. Teaching provisions are a channel to support the knowledge transfer from universities to businesses while increasing the value-added in production (Nelson and Phelps 1966). Thus, universities can act as a powerful magnet for attracting talented students from other parts of the country and even further afield (Seeber et al., 2014; Leporit et al., 2015). In addition, through their teaching at undergraduate and postgraduate level, universities have the potential to add to the stock of human capital by means of graduate recruitment into regional businesses, possibly following work placements as part of the student's degree. In this context, graduates can provide the gateway or connectivity for knowledge exchange between researchers and businesses. Furthermore, trained graduates are increasingly recognised as a source of creativity and entrepreneurial endeavours, particularly in relation to their capacity to spot opportunities and start-up businesses (Marzocchi et al., 2017; Astebro et al., 2014).

Finally, universities pursue wider engagement activities beyond commercialisation and collaborative research, and foster innovation capacity by enforcing social creativity and cultural development, providing the basis for the expansion of the knowledge economy. Cosh et al. (2009) argue that universities play underappreciated ‘public space’ functions including meeting and conference hosting, entrepreneurship centres and access to networks and personnel exchanges. Greater attention has been paid of late to the contribution of higher education not just to the exploitation of scientific research but also via outreach activities to the broader social and cultural environment. HEIs foster innovation capacity by enforcing social creativity and cultural development and by providing the basis for the expansion of the knowledge economy. Universities, particularly traditional civic universities such as Manchester, increasingly play a role as ‘anchor institutions’, understood as large, locally embedded organisations with the potential to influence the quality of life and economic development of places through its investments, employment and civic engagement decisions.

By acting as sites of interaction between previously disconnected communities of interest, such as business and corporate responsibility communities; sustainable development, human rights or consumer groups, universities can contribute to Responsible Research and Innovation (RRI) and Social Innovation. They can mediate to avoid the potential exclusion of people and communities from the knowledge economy (Benneworth and Cunha, 2015). Research activities in arts and humanities play a particularly important role here, although often their contributions to the innovation process are excluded from impact measurement because of commercialisation-focused indicators (Abreu and Grinevich, 2013; Olmos-Peñuela et al., 2014; Zukauskaite, 2012).

Thus, universities contribute to local economic growth, far beyond their research activities. Important spillovers effects come from skills and training as well as from research outreach and impact. These spillovers affect entrepreneurship and labour market provisions (locally and nationally), while universities make a major contribution to the capacity of a place to attract and retain talent.

5. Innovation in services and the creative economy

Services sectors have traditionally been seen as laggards in terms of innovation, and our models, theories and indicators of processes of innovation and diffusion are all built on research on manufacturing sectors. For the same reason, most innovation policy has been concerned with interventions which, whilst they might be in principle generic, are in practice designed with an idea of innovation and diffusion based on manufacturing.

Services are the major part of all advanced economies and usually the fastest growing part. The share of UK GDP attributed to productive industries (manufacturing plus extractive sectors) had declined from 41% in 1948 to just 14% by 2013. The service sectors collectively grew by 3% annually between 1990-2013, compared with 2.2% annual growth in GDP overall (Li, 2017). Some of the growth in the services sectors can been attributed to vertical disintegration and outsourcing of service activities that would formerly have been hidden (from the point of view of official statistics) within large manufacturing firms, and the growth in services provided alongside products (see below).

Miles (2005) notes that services sectors are primarily concerned with transforming the state of people, artefacts, information and knowledge, rather than producing tangible artefacts. However, there is also a trend towards the servitisation of manufacturing, in which the traditional distinction between the artefact or product and the intangible service is less clear-cut. On the one hand, manufacturers are offering value-added services alongside their products or switch to business models where a service is the main ‘product’ whilst the artefacts are used to deliver the product but not the focus of the transaction, usually with the aim of moving further up the value chain (e.g. the famous example of Rolls-Royce selling 'power by the hour' to customers or the transition of IBM into a IT services company underpinned by its hardware) (Bains et al., 2009).

Far from being laggards or late adopters of innovations produced by others, then, **many services firms are innovation-intensive**. However, **the models and practices of innovation in services sectors may be very different from those seen in traditional manufacturing sectors** in which innovation is largely located in the R&D process whilst production is routinised. Some services sectors, such as software, IT and R&D services, do have recognisable R&D activities and indeed their expenditure on R&D substantially exceeds the average for manufacturing (Abreu et al., 2010). Large financial services intermediaries too may organise innovation through R&D and are almost as R&D intensive as manufacturing firms (Abreu et al., 2010). However, **in most services sectors innovation is embedded in the production and delivery of the service**, especially where the service is bespoke and production processes must, of necessity, be non-repetitive.

In many cases services adopt a project-based form of organisation of innovation and production, whether intra-company or across a network of contractors and sub-contractors. **Project-based organisation of innovation can present challenges in terms of transmitting knowledge learned in the course of one time-limited project to another**, given that even intra-company project teams will typically disperse on successful completion. Examples of sectors where project-based forms of organisation and innovation predominate include the construction industry, the creative industries, many ICT companies and many so-called 'knowledge-intensive business services' such as architecture or advertising (Bettiol and Sedita, 2011; DeFillipi and Arthur, 1998; Gann and Salter, 2000). Nonetheless, Gallouj and Savona (2008) note that much of the literature on innovation in services remains preoccupied with technology at the expense of other kinds of innovation.

Digital innovation

ICT is a general-purpose technology and the widespread adoption of ICT as a process technology has transformed many sectors and has been the focus of much debate about productivity impacts. However, many ICT-enabled innovations today go beyond the application of ICT to business processes. Existing services have been transformed with new business models through digitalisation and the Internet, and new kinds of services have been made possible, with old or new business models (e.g. platform business models are not in themselves new, but digitalisation and the widespread adoption of Internet-enabled devices have hugely expanded the scope for platform business innovation).

New possibilities for processing data due to new digital technologies open up a new innovation dynamic with data becoming a new input to innovation (Guellec and Paunov (OECD), 2018). New products and services can be launched at a lower cost, innovative improvements can be more frequent (though they can also be more incremental, as with minor software updates). The availability of data, the presence of infrastructure and access to a market of potential users at low or no additional marginal cost, the relatively low cost of acquiring digital skills relative to science-based or engineering skills, and low costs of equipment and supporting services mean that **the barriers to entry are often very low in 'digital' sectors, unlike science-based and high-tech sectors**. This makes them more dynamic and entrepreneurial (Guellec and Paunov (OECD), 2018). It also means that many of the traditional assumptions and practices of innovation policy are unlikely to apply. Opening up access to data to potential innovators may be a more effective innovation policy for such sectors than promoting technological research, for instance (Guellec and Paunov (OECD), 2018).

Knowledge-Intensive Business Services

Some of the most rapid growth seen in the services sectors in recent years has been in financial services and business services. Within the broad category of business-to-business services particular attention has been paid to the importance of so-called Knowledge-Intensive Business Services (KIBS), a categorisation popularised by Miles et al. (1995). KIBS companies provide knowledge-intensive services to other organisations (not only businesses but also other kinds of organisations) (Miles, 2005). KIBS was not an official statistical categorisation but rather a conceptual one defined by understandings of knowledge intensity, though the knowledge intensity of different service sectors is now reflected in the most recent revision of the European NACE classification of economic activities (Schnabl and Zenker, 2013).

Whilst outsourcing and vertical disintegration do explain some of the growth in KIBS sectors, Miles (2005) notes that other drivers such as change in technology and proliferation of new technologies and change and growth in regulation are thought to be very important. In their recent bibliometric review of the KIBS literature J-Figueiredo et al. (2017) analysed 235 articles in the KIBS literature, noting the predominant focus on the key roles KIBS firms can play in innovation dynamics. Miles et al. (1995) had already noted that **KIBS firms act as users, sources and vectors of innovation in the economy, sometimes by transmitting useful knowledge to their clients but often by developing knowledge for or co-produce knowledge with their clients**. Thus, they are increasingly seen as key actors in innovation (eco)systems (J-Figueiredo et al. 2017).

The original Miles et al. (1995) study distinguishes between P-KIBS, more traditional professional services such as marketing, accountancy, architecture and design, business consultancy, or advertising, and T-KIBS, business services based on more scientific or technological knowledge bases, such as software development, IT consulting or the rapidly growing R&D services sector. More recently, Miles and others have also noted the creative element in some P-KIBS, such as architecture, design, marketing and advertising, coining the term C-KIBS to further differentiate such firms (Miles, 2012).

As noted above, **KIBS firms characteristically follow a project-based style of organising, meaning that the tacit knowledge and expertise of experienced workers and teams, on the one hand, and formalised knowledge management practices, on the other, are likely to be crucial resources for innovation**. Perhaps not surprisingly, expenditure on training in services firms substantially exceeds that in manufacturing (Abreu et al., 2010).

Innovation policy for KIBS and creative sectors?

What might innovation policies for knowledge intensive and creative services look like? Miles (2005) identifies a range of broad activities that might address the specific dynamics of innovation in KIBS, i.e.: measures to increase the production and mobility of highly-skilled labour; measures to increase access to KIBS services from disadvantaged organisations (e.g. SMEs or perhaps NGOs and social enterprise) and places; measures to liberalise trade in services; promoting professional qualifications and agreement of harmonised service standards; policy responses to the threat of business services offshoring (building on the stickiness of advanced knowledge and skills, e.g. by making places as attractive as possible for services innovators); supporting quality improvements in KIBS sectors; supporting the adoption of new knowledge and technology by KIBS firms; and promoting links between the private-sector knowledge base of KIBS and the public knowledge infrastructure and science base.

Rubalcaba et al. (2010) similarly argue for an emphasis on training and support for skills development in knowledge-intensive services sectors and on promoting services sector-science base linkages, and the intelligent use of public procurement to drive innovation in services both by stimulating competition and by stimulating standardization. NESTA (2007) argue that policy should move away from supporting the supply of specific innovations and towards creating and supporting the broader capacity to produce innovation and to build tailored innovation policies for different service sectors on sector-specific understandings.

Finally, Abreu et al. (2010) identify four broad areas for policy focus: training and development (noting that 'soft' disciplines are likely to be as if not more relevant in many cases than science, technology, engineering and mathematics (STEM) disciplines); a need to move away from a policy emphasis on the supply of novel technologies towards the adoption of technologies by services sector firms; a move away from a technology-focused view of university-industry knowledge exchange, and a preoccupation with patenting, spinouts and the like towards supporting a much broader range of interactions and interactive knowledge transfer mechanisms in which the social sciences and humanities are recognized as important as well as the physical and biomedical sciences (it should be noted that some existing knowledge transfer instruments, such as KTPs, are arguably already well-suited to services); and the urgent need for better metrics of innovation for services.

The implications of this are that any services firms are innovation-intensive but the practices of innovation may be very different from those in manufacturing. In particular, KIBS firms act as users, sources and vectors of innovation by transmitting useful knowledge to their clients and especially by developing knowledge for or co-producing knowledge with their clients. Because many services firms follow a project-based style of organising, tacit knowledge and expertise held by experienced workers and teams, and more formal knowledge management practices, are likely to be crucial resources for innovation.

6. Hidden Innovation

As highlighted earlier, much of the innovation at the firm level results from practices of absorption and adaption of externally-sourced knowledge and not from in-house R&D investments (Abreu et al., 2010; Barges-Gil et al., 2011). The overreliance on R&D measures to proxy innovation activities has caused an important problem: those sectors with low R&D spending (such as many traditional manufacturing sectors) or which are characterised by activities where investments in innovation are not R&D based (such as many services sectors) would not be considered innovative.

UK value added from knowledge-based services is far greater than that from high-tech manufacturing and knowledge services are significant for UK exports (Abreu et al., 2010). But where innovation involves inputs, outputs and practices that differ from the ones seen in medium and high-tech manufacturing, much of that innovation will be hidden from measurements based on traditional input metrics like R&D spending or output metrics such as patents, which are not relevant to many kinds of intangible services innovation. **As the services economy grows, traditional innovation indicators are likely to miss progressively more of the innovation activity going on in the economy**, though other approaches such as innovation surveys, may be more useful. At the same time, innovation policy instruments such as government subsidies for R&D or R&D tax credits may be of limited use in stimulating innovation and diffusion from services firms.

NESTA (2007) identify four types of 'hidden' innovation, based on a study of six (private and public) service sectors that perform poorly on traditional indicators of innovation (namely oil production, retail banking, construction, legal aid services, education and the rehabilitation of offenders). These are: Type I – technical R&D like innovation which is nonetheless excluded from R&D statistics because it is too close to operational use (e.g. the application of a new technology to monitoring of production in the oil industry); Type II – new forms of organisation (e.g. new construction processes); Type III – new combinations of existing or even mature technologies to deliver new or improved services (e.g. investments in bank IT systems and processes); Type IV – locally developed, small-scale incremental innovations that are not detected by managers or official statistics but which may diffuse and be widely adopted (e.g. incremental improvements in classroom practice of teachers, or of construction workers).

Writing about hidden innovation in the creative industries, Miles and Green (2008) also note these four types of hidden innovation. Looking at innovation survey data for creative sectors, and individual cases from videogames, product design, advertising (these two being KIBS sectors) and independent broadcast production, they note that **firms which create 'content' are more consistently innovative than those that distribute it**, that **the provision of new experiences is central to much innovation in these sectors**, that **many creative businesses struggle to formalise their innovation processes**, with much emphasis on project-based organisation and little on formal R&D or knowledge management, but that **'communities of practice' – networks both formal (such as professional associations) and less formal (e.g. industry networks or trusted groups of regular collaborators) are extremely important as sources of knowledge and ideas for innovation**.

Cunningham (2013) adds that the creative sectors are rarely organised for, oriented towards, or even aware of innovation policy support. As already noted above, many services sectors organise themselves around time-limited projects in which teams with a range of skills and knowledge produce a unique output. The profound challenge for innovation policy for creative sectors is that in such sectors each 'product' is novel – innovation as traditionally defined is ubiquitous. The cases of product design and advertising selected by Miles and Green also serves as useful examples of how important innovation in C-KIBS typically is to the unhidden innovation we see in manufacturing sectors – that is **much of the hidden innovation in creative sectors is not just hidden in the sense of being undocumented but is also hidden in the sense of its profound contribution to manufacturing innovation**.

Writing about hidden innovation in the construction and property sectors, Barrett et al. (2007) argue that **the poor reputation of these sectors regarding innovation is far from deserved**. As with many of the other services sectors we have considered in this section, construction is a project-based industry, and the discontinuous nature of project-based organisation can create challenges for learning and knowledge accumulation on the part of firms, and diffusion of knowledge between them. The fragmentation of the industry is also typically seen as a barrier to innovation, with a huge number of small firms and a very small number of large ones (a pattern seen to varying degrees in many other services sectors). Finally, the hyper-competitive nature of the industry and the need to win contracts in order to stay in business, may also encourage companies to be risk averse and to look to their suppliers as sources of innovation whilst at the same time squeezing them ruthlessly regarding costs. However, the authors argue that these characteristics overshadow innovation at the sector-level, e.g. through the adoption of new sector-wide standards, including through challenging demand for innovation from powerful users such as government; at the firm level, both through R&D and R&D like activities and through innovations in organisational practice, in training and staff development, in human resources management, and in other processes and practices; and finally at the project level, in which day-to-day problem solving by teams leads to the accumulation of incremental innovations that improve the project itself (but which can also, as noted by NESTA, (2007) get adopted and transferred 'under the radar').

The public sector is another potential site of hidden innovation. Public procurement - worth £270bn a year of goods, works and services in the UK (HM Government, 2017)—is a major influence on the private sector productivity and innovation (Edler and Georghiou, 2007; Uyarra and Flanagan, 2010). The public sector not only is a major customer for goods and services from the private sector and a potentially key shaper of innovation through regulation, but it is also a provider of services in its own right. Whilst policy-making and implementation can themselves be seen as innovation processes (Flanagan and Uyarra, 2016) most attention has been on innovation in this provision of public services. As with creative sectors, the term innovation has not until recently been commonly used in public services – terms such as reform and modernisation have been more common until recently (Cunningham and Karakasidou, 2009). When innovation is discussed, it is frequently in the limited sense of digitalisation of part or all of the provision of a service.

Public services innovation might be realised through new ways of organising public services, through the adoption of new technologies to manage or deliver services, or through the introduction of wholly new services (LGA, 2005). However, the public sector is typically not subject to the same kinds of competitive incentives to innovate that private sector firms theoretically are. It also has good reason to be more risk averse given that along with all the usual known, partly knowable and unknowable risks of innovation come with added political risks. **The promotion of public services innovation requires the generation of new ideas, rigorous experimentation, public and political acceptance of diverse experiments (versus complaints about post-code lotteries) and processes that diffuse learning and knowledge about successes and failures** (LGA, 2005; NESTA, 2007).

Measuring Hidden Innovation

NESTA (2007) argue that there is much potential in terms of new metrics for hidden innovation, but that this requires in-depth sectoral knowledge and the result would be an extensive basket of partial indicators tailored to each sector. There are at least two measurement problems here: the under-estimation of innovation activity in firms and sectors traditionally regarded as innovative (activities such as outsourced R&D, or the use of design or consultancy services by medium or high-tech manufacturing firms) (O'Brien 2016); and the under-estimation of innovation activities in other parts of the economy. In line with some of the features of services innovation identified above, new measures could include measures of human capital stocks and flows, investments in training, networking and collaboration, indicators of design-intensity such as use of design services or in-house design capabilities, measures of the novelty and scale of projects, etc.

Bloch and Bugge (2013) propose a framework for the measurement of public sector innovation derived from survey approaches to measuring innovation in the private sector (namely the Community Innovation Survey or CIS, represented in the UK by the UK Innovation Survey). Vergori (2014) notes that such innovation surveys, influenced by the evolving OECD Oslo Manual, have moved over time towards a more inclusive approach to the measurement of innovation in services. The trend of continuous revision of these definitions and approaches to better account for the diversity of innovation throughout the economy is likely to continue, and innovation surveys are always likely to be a key method of understanding the extent and nature of innovation across the economy.

However, whether national innovation surveys collect sufficient data to be useful at local or regional levels is unclear. Regional or city-regional agencies may need to explore collecting their own survey data at local level. New technical approaches such as web-scraping of company websites and other sources of publicly-available data that might shed light on activities related to innovation hold much promise (Gök, Waterworth, and Shapira 2015). Groups such as ODI Leeds and NESTA are creating tools to collect these kinds of data and dashboards to synthesise and visualize it. Examples include the ODI Leeds UK Tech Innovation Index (https://odileeds.org/projects/uk-tech-innovation-index/?options=true&datagroup=All%20Technology&location=null) and NESTA's innovation dashboard for the Welsh Government, Arloesiadur (https://arloesiadur.org/about).

The implications from this are that established innovation indicators miss progressively more of the innovation activity going on in the economy. Much hidden innovation is not just hidden in the sense of being undocumented but is also hidden in the sense of its contribution to manufacturing innovation. Communities of practice – networks both formal (such as professional associations) and less formal (e.g. industry networks or trusted groups of regular collaborators) – are extremely important as sources of knowledge and ideas for innovation. Innovation in public services requires the generation of new ideas, rigorous experimentation, public and political tolerance for experimentation, as well as processes that diffuse learning and knowledge about successes and failures.

7. Open innovation / ecosystems

Innovation has moved from being thought of as a closed and secretive process within a single organisation to one seen as a matter of open strategies and distributed innovation processes that span organisational boundaries. Over the past few decades, many firms have streamlined internal R&D and increased external interactions to substitute for limited internal capabilities (Chesbrough 2003). Open innovation is defined as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation" (Chesbrough, 2006, p. 1). This links to the use of practices such as in-sourcing, out-sourcing, joint-R&D, licensing and spin-outs as part of the innovation processes of individual firms. Chesbrough's Open Innovation framework has been widely adopted as a desirable innovation strategy/practice because it allows companies to escape the immediate restrictions of their internal capabilities, leverage external knowledge and create value from innovation assets that are outside the day-to-day innovation strategy, potentially reducing the development costs and risks associated with innovation. In particular, open innovation can enable companies to navigate inflows and outflows of knowledge that facilitate the acceleration of internal innovation and expand markets for the external use of internal innovation (Chesbrough, 2003, Chesbrough et al., 2006).

From the perspective of individual firms, the core dimension of open innovation is the direction of the innovation activity: whether it is 'inbound' (companies internalising the results of external R&D and knowledge-generating activities) or 'outbound' (bringing internal ideas to the market using processes mediated with other companies) (Chesbrough and Crowther, 2006). Companies that use both in-bound and out-bound open innovation are described as having a 'coupled' approach to innovation (Gassman and Enkel, 2004).

Open Innovation implies an extensive use of inter-organisational relationships to in-source external ideas from a variety of innovation sources (exploration) and to market internal ideas that fall outside the firm's current business model, using a range of external market channels (exploitation) (Dittrich and Duyster, 2007).

Accepting that innovation is a distributed process, with increasing dependence on 'open innovation' strategies, has focused attention on the bigger picture of these inter-organisational links. These links are increasingly conceptualised as the building blocks of ecosystems. Ecosystems can allow firms to create value which no single firm could create by itself (Adner, 2006). An entrepreneurial ecosystem is defined as the “combination of social, political, economic, and cultural elements within a region that support the development and growth” (Spigel, 2017, p. 50). In practice, ecosystems are economic communities supported by interacting firms and individuals that, over time, coevolve their capabilities and roles, and align themselves with the directions set by a focal firm (Moore, 1993, 1996). Interactions include simultaneous collaborative and competitive relationships, with connections focused on value networks and participants that may be geographically dispersed (Moore, 1993).

The term innovation ecosystem is used where innovation-related interdependencies have implications for decisions about specialisation, co-evolution and co-creation (Frels et al., 2003; Adner and Kapoor, 2010). Innovation ecosystems are not industry-specific (Moore, 1993, 1996; Iansiti and Levien, 2004; Teece, 2007). They encompass any entity that contributes to the shared offering (Iansiti and Levien, 2004) including production and use-side participants, providers of complementary assets and customers (Autio and Thomas, 2014), regulators, judiciary, education and research institutions that provide the institutional framework for the exchange of knowledge, people, services and finance supporting innovation (Coombs and Georghiou, 2002; Teece, 2007).

Not all business ecosystems are necessarily innovation ecosystems. The latter can be identified using a focal firm, brand or platform that connects production and use-side activities (Adner and Kapoor, 2010; Cusumano and Gawer, 2002; Gawer and Cusumano, 2002; Iansiti and Levien, 2004; Moore, 1993, 1996; Teece, 2007) and tracing “how new value is created and appropriated through innovation” (Autio and Thomas, 2014: 205).

Ecosystem thinking borrows from biological and evolutionary analogies and metaphors (Durst and Poutanen, 2013), and it is here that we get an idea of the underlying processes that take place within them. Metcalfe and Georghiou (1997) distinguish the following processes in evolving systems that support innovation: the generation of novelty that provides the material for change; the selection of superior technology through market competition and interactions between suppliers and users; and co-ordination through market and other non-market processes to resolve superior technology into patterns of economic activity and feedback for further variation (Metcalfe and Georghiou, 1997).

For instance, novelty generation is underpinned by interactions between populations of entities possessing different characteristics (Metcalfe and Georghiou, 1997). Environmental resource niches and localised adaptations can drive change amongst actors in the ecosystem community (Monge et al., 2008 in Durst and Poutanen, 2013). Innovating ecosystems require a constant and balanced cross-pollination of ideas, questions, knowledge and technology between the most important communities (Estrin, 2009 in Durst and Poutanen, 2013). Selection occurs through interactions between suppliers and users that evaluate technology and instigate the diffusion of superior technologies through particular value chains, and through processes of imitation (legal/non-legal, direct or indirect), which links it to intellectual property rights and the ability to appropriate ownership and control over particular knowledge/technology (Metcalfe and Georghiou, 1997).

Coordination processes develop demand, investment, productive capacity and learning, which creates endogeneity by structuring market coordination of innovation as the scale and range of applications grows. Directional inducements (feedback loops) are provided by user/supplier interactions, and the sequence and trajectory of technologies is shaped by profit streams and other financial mechanisms funding development (Metcalfe and Georghiou, 1997). **Integral to the shift to ecosystems thinking is the idea that**

innovation benefits from factors that are geographically bounded and firms' capabilities and competitiveness are shaped by the location where they originate.

8 Innovation and inequality

It is a widely held assumption that innovative, high-technology industries drive regional development and lead to greater prosperity in the places that host them. Innovation clusters are seen to lead to high multiplier effects (Moretti, 2012) and also attract a creative class that makes places wealthier and more attractive to investment (Florida, 2005).

However, the notion of **an automatic positive link between innovation and local economic development has begun to be questioned**. Radical innovation is associated with 'creative destruction' and therefore with losers as well as winners from innovation. **Innovation can render industries and skills obsolete, which has a differential impact on people and places**. For instance, a number of studies suggest that technology leads to a reduction of routine semi-skilled employment, which is more likely to be automated, and therefore to a more polarised labour market (Autor et al., 2003). **Innovation and structural change leads to redistribution of economic, political and social power**. This process is not space neutral. There is no guarantee that the replacement of old industries with new ones will happen in the same place and therefore that the impact of innovation will be felt locally, and regions will be able to capture the benefits of innovation (Sheamur, 2016).

Further, growing attention is being given to the relationship between innovation and inequality. **The most creative and innovative cities, such as Silicon Valley, tend to be the most unequal** (Florida, 2005; Walker, 2018). A growing 'creative class' may unleash processes of gentrification by the creative workers, leading to the displacement of other groups, raising housing costs and greater inequality (Lee, 2016). Other studies have sought to empirically test the relationship between innovation levels and widening income disparities more broadly. Lee (2011), for instance, found evidence of a link between innovation and inequality in European regions, although Lee and Rodriguez-Posé (2013) found only limited evidence of such a relationship in the US.

A key question for policy therefore is: What impact do economic development strategies based on developing high-tech industries have on income inequality and poverty reduction? While the assumption is that investment in innovative industries has a positive multiplier effect on the local economy (Moretti, 2012), other studies have found a more nuanced effect. For instance, Kemeny and Osman (2018), using US data on wages, employment and prices for the US, suggest that **high-technology employment has significant, positive, but modest effects on the real wages of workers in non-tradable sectors, compared to non-tech employment.** They conclude that there are wider benefits to be enjoyed from growth in a region's high-technology employment, but that these benefits are likely to be small.

There is also little evidence that economic development strategies based on developing high-tech industries reach those of low incomes. Lee and Rodriguez-Posé (2016) studied the effect of high-tech on urban poverty and wages of less educated workers. Using a panel of 295 Metropolitan Statistical Areas (MSAs) in the US between 2005 and 2011, they found evidence that tech employment increases wages for non-degree-educated workers but found no real impact on poverty reduction. In the UK, Lee and Clarke (2017) studied the economic impact of high-technology industries on less-well educated workers and found a positive jobs multiplier effect from high-technology sectors, but smaller than in US evidence. They also found that growth in tech sector leads to reduction in average wages for less well-educated workers.

Causality may also run the other way: **inequality may have an impact on innovation**. There is a growing body of evidence suggesting a range of negative social and economic externalities associated with growing inequality (Dorling, 2018), including environmental degradation and economic decline. Growing inequality may therefore have a detrimental effect on innovation and future growth. Gordon (2016) sees it as one of the factors, together with ageing population, lower quality of education and increasing debt that are likely to diminish future opportunities for innovation and growth in the US. According to Lee and Clarke (2017), **inequality may concentrate wealth in the hands of few individuals with relatively homogenous preferences and reduce incentives to innovation**. **It may also drive the affluent few towards protective, rent-seeking activities rather than more risky innovative ventures.**

Summing up, evidence suggests that **attracting high-technology industries to a region is not a sufficient condition for economic development, as its distributive effects might not impact inclusively on local living conditions**.

The benefits of innovation and structural change are more likely to be felt in places that display a considerable set of productive and human capabilities that make it more likely "that unexpected ideas can take hold and innovation will propel the economy forward" (Feldman et al., 2016, p. 16). Where those productive and human capabilities are lacking, additional policies are needed to develop the right conditions to enable as many actors as possible to participate productively in the economy (Iammarino et al., 2018) including addressing structural deficiencies such as skills and labour force participation. This is in line with recent recommendations on inclusive innovation policies, understood as interventions which *"aim to remove barriers to the participation of individuals, social groups, firms, sectors and regions that are underrepresented in innovation activities in order to ensure that all segments of society have the capacities and opportunities to successfully participate in and benefit from innovation"* (Planes-Satorra and Paunov, 2017, p.4; see also Lee 2019), and related concepts such as 'place-sensitive distributed development policy' (Iammarino et al., 2018) or 'distribution-sensitive innovation policies' (Zehavi and Breznitz, 2017). The latter argue that "policies formulated without concern for distributive outcomes can expand inequality" (p.329) **and therefore policies should consider *who* innovation is *for* and not just who produces it**.

In a recent report based on a review of innovation policy in ten countries, NESTA (2018) found that while governments around the world are starting to think about the impacts of innovation on society, they "do not yet have a clear idea about how to implement an inclusive innovation policy agenda effectively" (NESTA, 2018, p.4). On this basis they recommend: 1) a better understanding of the positive and negative effects of innovation on different groups; 2) that the trade-offs involved in pursuing broader participation in innovation (e.g. from hard to reach or excluded groups) are more effectively addressed; 3) open up priority-setting processes around innovation policy; 4) develop a more inclusive governance of innovation, including more effective cross-government collaboration.

The implications of this are that innovation-led growth may increase inequality, whilst greater inequality may in the long term reduce opportunities for innovation. This implies that we should not pursue innovation at any cost but carefully consider the social and spatial distribution of risks and benefits from innovation and enable as many actors as possible to participate productively in the economy (e.g. through investing in human capabilities and skills, and by increasing the quality and 'innovation potential' of 'routine' jobs).

9. Diversification and resilience

In parallel with greater awareness of distributional issues, the debate in innovation policy has recently also shifted from an emphasis on just enhancing R&D and growth, to a more transformative approach that aims to diversify an economy's industrial structure and underlying capabilities. This is influenced by new approaches to industrial policy (Rodrik, 2006) and recent policy innovations such as the smart specialisation agenda of the European Commission (Foray, 2018).

The debate on whether diversification or specialisation contributes to economic growth goes back to the classical writings of Marshall and Jacobs. Jacobs argued that it is not so much industry specialization but the opportunities that diversification brings in terms of knowledge spillovers that is key for economic growth. Building on this debate, regional scientists have drawn a distinction between related (within sectors) and unrelated diversification (between sectors) (Frenken et al., 2007) and argued **that an economy that consists of a wide set of technologically related industries is more conducive for growth. They argue that economies grow by diversifying or "branching out" into technologically related industries** as firms innovate more easily through the recombination of existing knowledge and routines embodied in the local industries (Boschma and Frenken, 2006).

Diversification and regional branching are also closely connected to the idea of regional resilience and are understood as the capacity of a regional or local economy to withstand, recover from and reorganize in the face of market, competitive and environmental shocks to its developmental growth path (Bristow and Healy, 2015; Boschma, 2015; Martin and Sunley, 2015). **Regions with a more diversified sectoral portfolio are assumed to be less sensitive to economic shocks** as the risk of being hit by a shock is spread among those sectors (Frenken et al., 2007) and they are better placed to find new combinations that may lead to new growth paths (Boschma, 2015). Empirical studies in different settings such as the Netherlands (Frenken et al., 2007), Great Britain (Bishop and Gripaios, 2010), Italy (Boschma and Iammarino, 2007; Quatraro, 2010), Spain (Boschma et al., 2012) have indeed found strong evidence supporting the importance of 'related variety' for regional economic performance, as measured by innovation and employment growth (for a review see Hidalgo et al., 2018).

Besides investigating the link between related variety and regional growth, relatedness among industries has been used to understand the entry of new industries into an economy. As Crespo et al. (2018, p.8) put it, "**the probability of a region to diversify into a new industrial or technological domain increases with the degree of relatedness between existing activities and the potential new growth trajectory**". This is because productive structures of countries and regions reflect particular capabilities, understood as domain-specific knowhow and routines which constitute the 'building blocks' (Hidalgo and Hausman, 2009) for the development of future products and technologies.

The idea, or 'principle', of relatedness (Hidalgo et al., 2018) therefore rests on two key premises. The first one is that **as economies grow and branch out, they become more complex**. This means that they develop the capabilities to produce greater diversity of products and services. More complex economies are able to grow faster because their economy is not only more diversified but also able to produce technologies that relatively few other places can produce (non-ubiquitous), which gives them competitive advantage. The second idea is that **the emergence of a new technology in a particular territory is not random but based on pre-existing knowledge and capabilities**. Development does not start from scratch but is path dependent, rooted in the historical economic structure of the region. But how do we measure this and what does this mean in practice for regions?

Measuring relatedness

Relatedness has been measured, for example, by using standard industrial classification (at lower levels of aggregation) (Frenken et al., 2007); the co-occurrence of products within the same plant, firm, region or country (Hidalgo et al., 2007); co-occurrence of technological classes within the same patent (Kogler et al., 2013; Balland et al., 2018); trade data (Boschma and Iammarino, 2015); citation flows; input–output tables; or labour mobility flows (Neffke et al, 2011).

Skills relatedness is for instance derived by looking at labour flows between industries. Industries are connected if they share the same skills-sets requirements. Neffke and Henning (2013) used longitudinal industry employment data in Sweden to identify the degree of revealed relatedness between industries and found that the probability of a firm diversifying into an industry with skill-related core activities is more than 100 times larger than the probability it will diversity into an unrelated industry.

Other studies have looked at the product relatedness. Using trade data as proxy for the economic structure of the economy, Hidalgo et al. (2007) developed the idea of the product space. Products are connected or proximate in the product space if they require similar cognitive capabilities. As a result, countries that are specialized in a 'dense' part of the product space have a relative advantage compared to those specialized in more disconnected products in terms of opportunities for productive transformation. Countries with more sophisticated or denser export baskets would tend to grow more, since they produce many products and also more complex products (that fewer countries export).

Other approaches have mapped the 'knowledge space' by analysing the co-occurrence of technological classes within the same patent in order to understand the opportunities for technological diversification. For instance, Balland et al. (2018) use regional patent data to study how EU regions diversify their innovative activities into new (related) technological domains, while Boschma et al. (2015) used USPTO data to show that entry into particular technology class in a city was more likely if they already had expertise in related technologies.

Some limitations of these approaches have been raised. For instance Radosevic (2017) argues that export data may not sufficiently reflect the industrial composition of a region or country (and may depend on factors such as trade openness and domestic market size), and may overlook productive capabilities embedded in non-traded sectors and services. The value added of exports may also be distorted by the role of global value chains, whereby countries with very sophisticated export markets may in effect just engage in low-complexity assembly activities (Radosevic, 2017). Using final products may, according to Andreoni and Chang (2018), be misleading as similar products may be produced using different technologies and different products may be produced by using similar technologies. Finally using patent data as proxy of the knowledge space is likely to be biased towards sectors that show greater patent intensity and therefore risks overlooking (potentially greater) diversification opportunities in other sectors.

In addition, upgrading is generally understood in terms of moving to a more complex product or technological domain, paying less attention to improvements in terms of quality, process innovation, or new business models which may be equally or even more transformative (Radosevic, 2017). So, for instance, a textile manufacturer may apply or integrate emerging generic technologies such as nanotechnology in their existing product portfolio or manufacturing process (Tanner, 2014; Foray; 2015). This is particularly important for non-core regions lacking a complex and diversified economic structure and therefore presenting less opportunities for diversification based on technological opportunities alone. Such general-purpose technologies are often available globally rather than locally, so regions would not need to develop them from scratch (Asheim et al., 2018).

It is also important to remember that countries and regions are not closed economic systems, and the technological knowledge present in them (as expressed for instance by patent data) does not guarantee that the productive capacity to exploit such knowledge will be present in the same location. Conversely, while diversification is a localised process, it may be fed not only by local inputs (Asheim et al., 2018). Extra-regional linkages through e.g. trade or research are key determinants of local knowledge accumulation.

This is relevant when undertaking such analysis at lower levels of aggregation. Take for instance Lancashire, which is one of the NUTS2 regions analysed by Balland et al (2018). Historically based on shipbuilding and defence, Lancashire is not a very diversified economy and presents few opportunities for productive diversification. It is however proximate to the much more diversified and knowledge intensive Greater Manchester area. Analyzing Lancashire in isolation may thus miss out on key opportunities or lead to duplication of efforts and resources. And looking only at Greater Manchester may neglect the research capabilities present in Cheshire East and the opportunities for technological diversification emerging from them.

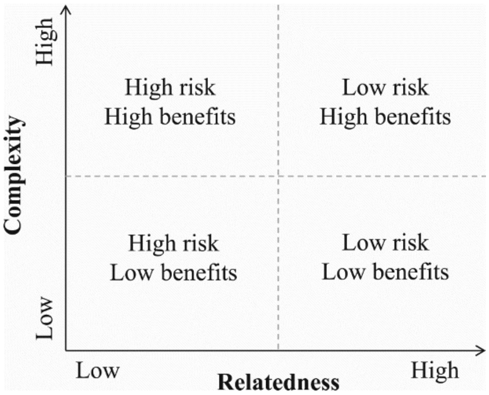
A final limitation is the lack of consideration of the political economy context in which diversification processes take place, including the role of the state (Andreoni and Chang, 2018). Seeking to address the relative neglect of the institutional dimension of industrial change, Boschma and Capone (2015) found that countries with different varieties of capitalism may follow different patterns of diversification. Relatedness was found to be a stronger driver of diversification in presence of institutions associated with coordinated market economies, while countries with institutions typical of liberal market economies were more likely to move into unrelated products.

How useful are these approaches to inform innovation policy for regions and city regions?

These approaches are a useful approximation to the opportunity space for regions to move on to. Balland et al. (2018) developed a framework for identifying technological opportunities for regions, **based on relatedness density and knowledge complexity of individual technologies[1].** This leads to a framework which indicates the relative risks and benefits of different alternatives (see Figure 1). So, for instance, the top-left quadrant indicates areas which are highly complex, therefore yielding high benefits, but also un-related to pre-existing regional capabilities and therefore carry greater risk. They involve taking big jumps in the knowledge space, which is riskier and challenging because such new combinations typically require knowledge exchange amongst cognitively (and often geographically) remote agents. The bottom-left quadrant represents areas which are highly related and therefore feasible but with relatively low value added. The top-right quadrant is the safest option as it involves choosing a technology that is closer to the existing knowledge base.

[1] Knowledge complexity is a measure of how ubiquitous the technology is (based on patent classes). The more complex the technology, the greater are the expected benefits for the region in terms of regional development potential. Relatedness on the other hand is a measure of how proximate that technology is to existing regional capabilities (in other words, to what extend the capabilities required to develop that technology are present in the region).

Figure 1: Policy framework to assess industries and technological domains



Source: Balland et al. (2018)

Such a framework can help develop regional policies based on regions' productive capabilities, thus avoiding a one-size-fits-all approach. It may also reveal emerging areas of specialization that have strong value added but are not currently well supported or funded. Technological relatedness analyses should help regions understand the trade-offs and cost opportunities of their diversification choices.

Asheim et al. (2018) question whether we should rely on historical data of relatedness to inform policy decisions, since it risks deducing the conditions for future industrial dynamics directly from conditions supportive of industrial development in the past. Conditions of the past may not be long lasting, political preferences may have changed and nominally similar instruments may no longer be effective. For instance, Bessen (2015) argues that current government policies in the US are much less effective than previous ones in terms of their capacity to support development and adoption of technologies.

As mentioned above, greater attention to political economy issues is needed in these analyses**. In order to fully understand the opportunity space for regions we need to consider the 'policy space' available to them. Policies, like technologies, are path dependent and tend to evolve in related portfolios due to institutional inertia and preferences of policy makers. More emphasis needs to be paid to what are the opportunities for policy action.** This not only includes paying attention to implementation issues (e.g., financial and human resource demands, political considerations) when deciding which strategy to follow and which types of policies to pursue (Andreoni and Chang, 2018), but also to what policy levers regions actually possess, including the administrative capabilities needed and the costs associated with the interventions (Uyarra and Flanagan, 2010). Certain technological areas identified as having strong value added may be difficult to steer or support using the tools available to regions (requiring complex multi-level or inter-regional policy coordination and alignment), while other, relatively lower added value activities, may be more amenable to regional policy intervention. So, a region may choose a policy tool because it is less demanding or easier to administer. As Rodrik (2007; p.17) puts it, "a first-best policy in the wrong institutional setting will do considerably less good than a second-best policy in an appropriate institutional setting".

Turning now to the normative implications of these approaches (What should regions do?), a key question is whether a strategy of related diversification is better or easier than unrelated diversification. For this question, and the associated role for policy, there is no consensus in the literature. If past upgrading happened organically, with little or no help from public policy, it could be argued that the additionality of any policy intervention would be low as those countries are likely to move into those areas anyway. In economic parlance, we may speak of market failure only if regions choose to move to unrelated areas, as those connections are less likely to happen (Frenken, 2017). Or, it could be argued that even if there are 'natural' paths of progression between different but related products or technologies, policy intervention may accelerate the move from one to another, through for instance entrepreneurship support and investment in knowledge infrastructure.

By only diversifying into related activities and therefore strengthening existing development paths, regions and countries may eventually run out of opportunities (path exhaustion) (Frenken, 2017). **In contrast, recombining more distant pieces of knowledge (unrelated variety) has been associated with radical innovation** (Castaldi et al., 2015). Historical examples of development such as the 'miracle' economies of East Asia show how deliberate efforts to move into unrelated areas played a major part in their economic success (Andreoni and Chang, 2018). Pinheiro et al. (2018) studied the economic diversification paths of 93 countries between 1965 and 2014 and found that countries entering more unrelated activities experienced a small but significant increase in subsequent economic growth performance.

Unrelated diversification may be the only alternative for less developed regions. Kuusk and Martynovich (2018) show that knowledge spillovers between related industries occur primarily in metropolitan and/or technology intensive settings. On the other hand, they suggest that in more peripheral regions locked in 'old' technological trajectories, spillovers between 'related' industries may not be enough to stimulate growth. Pinheiro et al. (2018) found that the countries successfully enter relatively more unrelated activities were at an intermediate level of economic development and had a relatively high level of human capital. In the words of Hausmann (2016; p.15), peripheral countries and regions often face a **chicken-and-egg problem: "You do not accumulate know-how in things you do not do and it is impossible to do things without the requisite know-how".** Further diversification may therefore not be possible unless new capabilities are acquired.

It has therefore **been argued that a combination of related and unrelated variety should be pursued.** Asheim et al. (2018), for instance, recommends a combination of sector-neutral (aimed at building and upgrading generic competencies) and non-neutral, vertical policies aimed at increasing the exploration capacity of firms.

Unrelated diversification can be stimulated by promoting crossovers between unrelated technologies and industries that are present in an economy, and one way of doing that is through the creation of interfaces or 'platforms' that connect different sphere of specialized knowledge to address societal or system-level challenges (i.e. the demand for solutions) (Janssen, 2015; see also Cooke, 2012). This is more conducive to transformative change because, "whereas a regular branching process might lead those firms to pursue their idiosyncratic trajectories, being involved in fighting societal challenges can expose them to knowledge from domains they would otherwise never look at" (Janssen, 2015, p. 9).

This can be articulated through defining particular "missions", linked to higher level societal challenges. Mazzucato (2018) makes a case for 'granularity', suggesting that societal challenges, like sustainable development goals, for example, "are useful to ensure focus" but are "too broad to be actionable" (p. 10). **The identification of particular missions brings greater focus and a level of granularity and allows the setting up of targets and timings**.

The importance of place is crucial in articulating those missions, since as Wanzenböck and Frenken argue, challenges do not "present themselves as the same for every region or nation, as underlying problems affect places in different ways and to different extents. Despite of labels of ‘grand’ and ‘global’, the challenges remain contextual” (2018, p.11). There is a **danger however that missions are defined top-down and remain detached from local realities and not made operational and concrete in ways that relate to the public** (Dale-Clough et al., forthcoming).

The implications of this are that the patterns of structural diversification of regional economies are an important consideration when designing regional innovation strategies. Policies need to build from existing strengths from which new specialisms can emerge and regions can diversify into in order to sustain competitive advantage. Regions should pursue a combination of related and unrelated variety by supporting ‘spill-overs’ and value when combined. This can be done by linking existing regional industrial and knowledge strongholds in novel ways to solve specific societal challenges through well-articulated ‘missions’. Finally, processes of diversification are strongly localised, as they depend on local interactions, but they are fed by both local and global inputs. Extra-regional linkages through e.g. trade or research are also key determinants of related and especially unrelated diversification.

References

Abreu, Maria, and Vadim Grinevich (2013). “The Nature of Academic Entrepreneurship in the UK: Widening the Focus on Entrepreneurial Activities.” *Research Policy* 42, no. 2: 408–22. https://doi.org/10.1016/j.respol.2012.10.005.

Abreu, Maria, Vadim Grinevich, Michael Kitson, and Maria Savona. (2010). ‘Policies to Enhance the “Hidden Innovation” in Services: Evidence and Lessons from the UK: The Service Industries Journal: Vol 30, No 1’. The Services Industries Journal 30 (1): 99–118.

Adner, Ron (2006). “Match Your Innovation Strategy to Your Innovation Ecosystem.” *Harvard Business Review*, 12.

Adner, Ron, and Rahul Kapoor (2010). “Value Creation in Innovation Ecosystems: How the Structure of Technological Interdependence Affects Firm Performance in New Technology Generations.” *Strategic Management Journal* 31, no. 3 (2010): 306–33. https://doi.org/10.1002/smj.821.

Andreoni, A., & Chang, H. J. (2018). The political economy of industrial policy: Structural interdependencies, policy alignment and conflict management. *Structural Change and Economic Dynamics*. Available online 29 October 2018.

Arranz, Nieves, and J. Carlos Fdez. de Arroyabe (2008). “The Choice of Partners in R&D Cooperation: An Empirical Analysis of Spanish Firms.” *Technovation* 28, no. 1) 88–100. https://doi.org/10.1016/j.technovation.2007.07.006.

Arrow, Kenneth J. (1962) "Economic welfare and the allocation of resource for inventions, in the rate and direction of inventive activity: economic and social factors." *N. Bureau*.

Asheim, A. Fitjar, R. Herstad, SH, Hjertvikrem N, (2018) Diversity and beyond for new path development: Broadening the scope for new perspectives on innovation theory and policy. *The Research Council of Norway*

Asheim, Bjørn T., and Lars Coenen (2005). “Knowledge Bases and Regional Innovation Systems: Comparing Nordic Clusters.” *Research Policy*, Regionalization of Innovation Policy, 34, no. 8: 1173–90. https://doi.org/10.1016/j.respol.2005.03.013.

Astebro, Thomas, Holger Herz, Ramana Nanda, and Roberto A. Weber (2014). “Seeking the Roots of Entrepreneurship: Insights from Behavioral Economics.” *Journal of Economic Perspectives* 28, no. 3: 49–70. https://doi.org/10.1257/jep.28.3.49.

Autor, D. H., Levy, F., & Murnane, R. J. (2003). The skill content of recent technological change: An empirical exploration. *The Quarterly journal of economics*, *118*(4), 1279-1333.

Baines, T.S., Lightfoot, H.W., Benedettini, O. and Kay, J.M., (2009). The servitization of manufacturing: A review of literature and reflection on future challenges. *Journal of manufacturing technology management*, *20*(5), pp.547-567.

Balland, P. A., Boschma, R., Crespo, J., & Rigby, D. L. (2018). Smart specialization policy in the European Union: relatedness, knowledge complexity and regional diversification. *Regional Studies*, 1-17.

Balland, P.A. (2016). Relatedness and the Geography of Innovation, in: R. Shearmur, C. Carrincazeaux and D. Doloreux (eds) Handbook on the Geographies of Innovation. Northampton, MA: Edward Elgar.

Barge-Gil, A., Jesus Nieto, M. and Santamaria, L., (2011). Hidden innovators: The role of non-R&D activities. *Technology analysis & Strategic management*, *23*(4), pp.415-432.

Barrett, P.S., Abbott, C., Sexton, M.G. and Ruddock, L., (2007). Hidden innovation in the construction and property sectors. *RICS Research paper series*, *7*(20), pp.1-21.

Bettiol, M. and Sedita, S.R., (2011). The role of community of practice in developing creative industry projects. *International Journal of Project Management*, *29*(4), pp.468-479.

Bishop, P., & Gripaios, P. (2010). Spatial externalities, relatedness and sector employment growth in Great Britain. *Regional Studies*, *44*(4), 443-454.

Bloch, Carter, and Markus M. Bugge. (2013). ‘Public Sector Innovation—From Theory to Measurement’. Structural Change and Economic Dynamics 27 (December): 133–45. https://doi.org/10.1016/j.strueco.2013.06.008.

Boschma, R. (2015). Towards an evolutionary perspective on regional resilience. *Regional Studies*, *49*(5), 733-751.
Boschma, R., & Capone, G. (2015). Institutions and diversification: Related versus unrelated diversification in a varieties of capitalism framework. *Research Policy*, *44*(10), 1902-1914.
Boschma, R., & Frenken, K. (2011). The emerging empirics of evolutionary economic geography. *Journal of economic geography*, *11*(2), 295-307.
Boschma, R., & Iammarino, S. (2009). Related variety, trade linkages, and regional growth in Italy. *Economic geography*, *85*(3), 289-311.
Boschma, R., Balland, P. A., & Kogler, D. F. (2014). Relatedness and technological change in cities: the rise and fall of technological knowledge in US metropolitan areas from 1981 to 2010. *Industrial and corporate change*, *24*(1), 223-250.
Boschma, R., Minondo, A., & Navarro, M. (2012). Related variety and regional growth in Spain. *Papers in Regional Science*, *91*(2), 241-256.
Boucher, Gerry, Cheryl Conway, and Els Van Der Meer (2003). "Tiers of Engagement by Universities in Their Region's Development." *Regional Studies* 37, no. 9: 887–97.
Brandenburger, Adam M., and Barry J. Nalebuff. (1997) "Co□opetition: Competitive and Cooperative Business Strategies for the Digital Economy." *Strategy & Leadership* 25, no. 6: 28–33.
Breschi, Stefano, and Francesco Lissoni (201). "Knowledge Spillovers and Local Innovation Systems: A Critical Survey." *Industrial and Corporate Change* 10, no. 4: 975–1005. https://doi.org/10.1093/icc/10.4.975.
Bristow, Gillian, and Adrian Healy (2015). "Crisis response, choice and resilience: insights from complexity thinking." *Cambridge Journal of Regions, Economy and Society* 8, no. 2: 241-256.
Castaldi, C., Frenken, K., & Los, B. (2015). Related variety, unrelated variety and technological breakthroughs: an analysis of US state-level patenting. *Regional studies*, *49*(5), 767-781.
Chesbrough, H. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston, Mass: Harvard Business School Press.
Chesbrough, H. and Crowther, A. (2006). "Beyond High Tech: Early Adopters of Open Innovation in Other Industries." *R&D Management* 36, no. 3: 229–36.
Chesbrough, H., Vanhaverbeke, W. and West, J. (2006). *Open Innovation: Researching a New Paradigm*. OUP Oxford, 2006.
Cohen, W.M., and Levinthal, D.A. (2990). "Absorptive Capacity: A New Perspective on Learning and Innovation." *Administrative Science Quarterly* 35, no. 1: 128–52.
Cooke, P. (2012). From clusters to platform policies in regional development. European planning studies, 20(8), 1415-1424.
Coombs, R. and Georghiou, L. (2002). "A New 'Industrial Ecology.'" *Science* 296, no. 5567: 471–471.
Cosh, A. and Hughes, A. (2010). "Never Mind the Quality Feel the Width: University–industry Links and Government Financial Support for Innovation in Small High-Technology Businesses in the UK and the USA." *The Journal of Technology Transfer* 35, no. 1: 66–91.
Crespo, J., Balland, P. A., Boschma, R., & Rigby, D. (2017). Regional Diversification Opportunities and Smart Specialization Strategies. *Publications Office of the European Union*.
Cunha, Jo. and Benneworth, P. (2015). "Universities' Contributions to Social Innovation: Reflections in Theory & Practice." *European Journal of Innovation Management* 18, no. 4 (October 7, 2015): 508–27.
Cunningham, PN & Karakasidou, A (2009), 'Innovation in the Public Sector'. Policy Brief No 2. European Trend Chart on Innovation Policy, European Commission.
Cunningham, Stuart. 2013. Hidden Innovation: Policy, Industry and the Creative Sector. University of Queensland Press.
Dale-Clough, L. Uyarra, E. and Ribeiro, B. Responsible regional innovation policy: public value from public procurement for innovation, forthcoming in European Planning Studies.
David, Paul A. (1985)"Clio and the Economics of QWERTY." *The American Economic Review* 75, no. 2: 332–37.

DeFillippi, R.J. and Arthur, M.B., (1998). Paradox in project-based enterprise: The case of film making. *California management review*, *40*(2), pp.125-139.
Dittrich, Koen, and Geert Duysters. “Networking as a Means to Strategy Change: The Case of Open Innovation in Mobile Telephony.” *Journal of Product Innovation Management* 24, no. 6 (2007): 510–21. https://doi.org/10.1111/j.1540-5885.2007.00268.x.
Dodgson, Mark, David M. Gann, and Nelson Phillips. *The Oxford Handbook of Innovation Management*. OUP Oxford, 2013.
Dorling, D. (2018). Inequality in Advanced Economies. *The New Oxford Handbook of Economic Geography*, 39.
Dosi, G. (1988). “Sources, Procedures, and Microeconomic Effects of Innovation.” *Journal of Economic Literature* 26, no. 3 (1988): 1120–71.
Durst, S. and Poutanen, P. (2013). “Success Factors of Innovation Ecosystems - Initial Insights from a Literature Review.” Aalto University Publication series SCIENCE + TECHNOLOGY
Edler, J., & Georghiou, L. (2007). Public procurement and innovation—Resurrecting the demand side. *Research policy*, *36*(7), 949-963.
Feldman, M., Hadjimichael, T., Lanahan, L., & Kemeny, T. (2016). The logic of economic development: A definition and model for investment. *Environment and Planning C: Government and Policy*, *34*(1), 5-21.
Figueiredo, Ronnie, Júlio Vieira Neto, Osvaldo Luiz Gonçalves Quelhas, and João José de Matos Ferreira. 2017. ‘Knowledge Intensive Business Services (KIBS): Bibliometric Analysis and Their Different Behaviors in the Scientific Literature: Topic 16 – Innovation and Services’. RAI Revista de Administração e Inovação 14 (3): 216–25.
Flanagan, K. and Uyarra, E., 2016. Four dangers in innovation policy studies–and how to avoid them. *Industry and Innovation*, *23*(2), pp.177-188.
Florida, R. (2005). *Cities and the creative class*. Routledge.
Foray, D. (2018). Smart specialization strategies as a case of mission-oriented policy—a case study on the emergence of new policy practices. *Industrial and Corporate Change*, *27*(5), 817-832.
Frels, Judy K. (2003), Tasadduq Shervani, and Rajendra K. Srivastava. “The Integrated Networks Model: Explaining Resource Allocations in Network Markets.” *Journal of Marketing* 67, no. 1: 29–45.
Frenken, K. (2017). A complexity-theoretic perspective on innovation policy. *Complexity, Innovation and Policy*, 35-47.
Frenken, K., Van Oort, F., & Verburg, T. (2007). Related variety, unrelated variety and regional economic growth. *Regional studies*, *41*(5), 685-697.
Gallouj, Faïz, and Maria Savona. (2008). ‘Innovation in Services: A Review of the Debate and a Research Agenda’. Journal of Evolutionary Economics 19 (2): 149.
Gann, D.M. and Salter, A.J., (2000). Innovation in project-based, service-enhanced firms: the construction of complex products and systems. *Research policy*, *29*(7-8), pp.955-972.
Gassmann, Oliver, and Ellen Enkel. (2004)“Towards a Theory of Open Innovation: Three Core Process Archetypes.” Lissabon, 2004. https://www.alexandria.unisg.ch/274/.
Gertler, Meric S., and T Vinodrai. (2005) “Anchors of Creativity: How Do Public Universities Create Competitive and Cohesive Communities.” *University of Toronto Press*.
Gertler, Meric S., David A. Wolfe, and David Garkut (2000). “No Place like Home? The Embeddedness of Innovation in a Regional Economy.” *Review of International Political Economy* 7, no. 4: 688–718.
Gök, Abdullah, Alec Waterworth, and Philip Shapira. (2015). ‘Use of Web Mining in Studying Innovation’. Scientometrics 102 (1): 653–71. https://doi.org/10.1007/s11192-014-1434-0.
Gordon, R. J. (2016). *The rise and fall of American growth: The US standard of living since the civil war* (Vol. 70). Princeton University Press.
Guellec, D. and C. Paunov (2018), "Innovation policies in the digital age", *OECD Science, Technology and Industry Policy Papers*, No. 59, OECD Publishing, Paris, https://doi.org/10.1787/eadd1094-en.
Haskel, Jonathan, and Stian Westlake. (2017) *Capitalism without Capital: The Rise of the Intangible Economy*. Princeton, New Jersey: Princeton University Press.

Hausmann, R. (2016). Economic Development and the Accumulation of Know-how. *Welsh Economic Review*, *24*, 13-16.
Hidalgo, C. A., & Hausmann, R. (2009). The building blocks of economic complexity. *Proceedings of the national academy of sciences*, *106*(26), 10570-10575.
Hidalgo, C. A., Klinger, B., Barabási, A. L., & Hausmann, R. (2007). The product space conditions the development of nations. *Science*, *317*(5837), 482-487.
Hidalgo, C.A., Balland, P.A., Boschma, R., Delgado, M., Feldman, M., Frenken, K., Glaeser, E., He, C., Kogler, D.F., Morrison, A. and Neffke, F., 2018, July. The principle of relatedness. In *International Conference on Complex Systems*(pp. 451-457). Springer, Cham.
Hippel, Eric von (1994). *The Sources of Innovation*. Reprint edition. New York Oxford: Oxford University Press.
HM Government (2017) Industrial Strategy: building a Britain fit for the future.
Iammarino, S., Rodríguez-Pose, A., & Storper, M. (2018). Regional inequality in Europe: evidence, theory and policy implications. *Journal of Economic Geography*.
Iansiti, M., and R Levien (2004). “Strategy as Ecology.” *Harvard Business Review*, 2004, 1.
Janssen, M. J. (2018). What bangs for your buck? Assessing the design and impact of Dutch transformative policy. *Technological Forecasting and Social Change*. Volume 138, Pages 78-94
Katz, Michael L., and Carl Shapiro (1985). “Network Externalities, Competition, and Compatibility.” *The American Economic Review* 75, no. 3: 424–40.
Kemeny, T., & Osman, T. (2018). The wider impacts of high-technology employment: Evidence from US cities. *Research Policy*.
Keupp, Marcus Matthias, Maximilian Palmié, and Oliver Gassmann (2012). “The Strategic Management of Innovation: A Systematic Review and Paths for Future Research.” *International Journal of Management Reviews* 14, no. 4: 367–90.
Kogler, D. F., Rigby, D. L., and Tucker, I. (2013). Mapping knowledge space and technological relatedness in us cities. European Planning Studies, 21(9):1374–1391.
Kogut, Bruce, and Udo Zander. (1992) “Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology.” *Organization Science* 3, no. 3: 383–97. https://doi.org/10.1287/orsc.3.3.383.
Kuusk, K., & Martynovich, M. (2018). *What kind of related variety for long-term regional growth?* (No. 1834). Utrecht University, Department of Human Geography and Spatial Planning, Group Economic Geography.
Landau, Ralph, Nathan Rosenberg, and National Academy of Engineering. *The Positive Sum Strategy: Harnessing Technology for Economic Growth*. National Academies, 1986.
Laursen, Keld, and Ammon Salter (2006). “Open for Innovation: The Role of Openness in Explaining Innovation Performance among U.K. Manufacturing Firms.” *Strategic Management Journal* 27, no. 2: 131–50.
Lee, N. 2011. Are innovative regions more unequal? Evidence from Europe. *Environment and Planning C: Government and Policy*, *29*(1), 2–23.
Lee, N. 2019. Inclusive Growth in cities: a sympathetic critique. *Regional Studies*, 53(3), 424-434.
Lee, N., & Clarke, S. (2017). *Who gains from high-tech growth? High-technology multipliers, employment and wages in Britain* (No. 2017-14). SPRU-Science and Technology Policy Research, University of Sussex.
Lee, N., & Rodríguez-Pose, A. (2016). Is there trickle-down from tech? Poverty, employment, and the high-technology multiplier in US cities. *Annals of the American Association of Geographers*, *106*(5), 1114-1134.
Leiponen, Aija. (2005) “Skills and Innovation.” *International Journal of Industrial Organization* 23, no. 5: 303–23.
LGA/IDEA/NSG (2005) Innovation in Public Services Literature Review, Innovation in Public Services Project, Local Government Association, Improvement and Development Agency and National School of Government, mimeo, IDeA Knowledge 09/05.
Li, X (2017) Innovation Process in Research and Development Service Firms: The Case of the UK. PhD Thesis, University of Manchester.

Lundvall, Bengt-Åke. (1992) *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. Pinter Publishers, 1992.
Makadok, R. (2001)"Toward a Synthesis of the Resource-Based and Dynamic-Capability Views of Rent Creation." *Strategic Management Journal* 22, no. 5 (2001): 387–401.
Marzocchi, C., Kitagawa, F. & Sánchez-Barrioluengo, M. (2017). Evolving missions and university entrepreneurship: academic spin-offs and graduate start-ups in the entrepreneurial society. Journal of Technology Transfer (in print). https://doi.org/10.1007/s10961-017-9619-3
Metcalfe, Stan, and Luke Georghiou (1997). "Equilibrium and Evolutionary Foundations of Technology Policy." *CRIC Discussion Papers* 3.
Miles, I., Kastrinos, N., Bilderbeek, R., den Hertog, P., Flanagan, K., Huntink, W. and Bouman, M., (1995). Knowledge-intensive business services: their role as users, carriers and sources of innovation. *Report to the EC DG XIII Sprint EIMS Programme, Luxembourg*.
Miles, Ian. (2005). 'Knowledge Intensive Business Services: Prospects and Policies'. Foresight 7 (6): 39–63. https://doi.org/10.1108/14636680510630939.
Miles, I. and Green, L., (2008). *Hidden innovation in the creative industries*. NESTA Futurlab.
Miles, Ian. (2006) "Innovation in Services." In *The Oxford Handbook of Innovation*, J. Fagerberg, D. Mowery & R. Nelson (Eds). Oxford: Oxford University Press, n.d.
Miles, I., (2012). KIBS and knowledge dynamics in client-supplier interaction. In *Exploring Knowledge-Intensive Business Services* (pp. 13-34). Palgrave Macmillan, London.
Moore, JF. (2003) "Predators and Prey: A New Ecology of Competition." *Harvard Business Review* 71, no. 3: 75.
Moretti, E. (2012). *The new geography of jobs*. Houghton Mifflin Harcourt.
Mowery, David C., and Nathan Rosenberg (1999). *Paths of Innovation: Technological Change in 20th-Century America*. Cambridge University Press.
Neffke, F. and Henning, M. S. (2013). Skill relatedness and firm diversification. Strategic Management Journal, 34(3):297-316.
Neffke, F., Henning, M. S., and Boschma, R. (2011). How do regions diversify over time? industry relatedness and the development of new growth paths in regions. Economic Geography, 87(3):237–26
Nelson, Richard R. (1959) The Simple Economics of Basic Scientific Research. *Journal of political economy*, *67*(3), 297-306.
Nelson, Richard R., and Edmund S. Phelps (1966). "Investment in Humans, Technological Diffusion, and Economic Growth." *The American Economic Review* 56, no. 1/2: 69–75.
NESTA (Harris, D.M. and Halkett, R.), (2007). *Hidden innovation: how innovation happens in six low innovation sectors*. NESTA.
Nonaka, Ikujiro. (1994) "A Dynamic Theory of Organizational Knowledge Creation." *Organization Science* 5, no. 1: 14–37. https://doi.org/10.1287/orsc.5.1.14.
O'Brien, Kieran. 2016. 'Revealing Hidden Innovation: Patterns of External Innovation Investment in Australian Businesses'. Technology Innovation Management Review 6 (6): 41–48.
OECD (2018) "Oslo Manual 2018 | READ Online." OECD iLibrary. Accessed December 19, 2018. https://read.oecd-ilibrary.org/science-and-technology/oslo-manual-2018_9789264304604-en.
Olmos-Peñuela, Julia, Elena Castro-Martínez, and Pablo D'Este. (2014) "Knowledge Transfer Activities in Social Sciences and Humanities: Explaining the Interactions of Research Groups with Non-Academic Agents." *Research Policy* 43, no. 4: 696–706. https://doi.org/10.1016/j.respol.2013.12.004.
Pinheiro, F.L., Alshamsi, A., Hartmann, D., Boschma, R. and Hidalgo, C., 2018. Shooting Low or High: Do Countries Benefit from Entering Unrelated Activities?. *arXiv preprint arXiv:1801.05352*.
Powell, Walter W., Kenneth W. Koput, and Laurel Smith-Doerr (1996). "Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology." *Administrative Science Quarterly* 41, no. 1: 116–45.
Quatraro, F. (2010). Knowledge coherence, variety and economic growth: Manufacturing evidence from Italian regions. *Research Policy*, *39*(10), 1289-1302.

Radosevic, S., (2017). Assessing EU Smart Specialisation Policy in a Comparative Perspective, in: Radosevic, S., Curaj, A., Gheorghiu, R., Andreescu, L., Wade, I. (Eds.), Advances in the Theory and Practice of Smart Specialization. Academic Press, pp. 2–37.
Rogers, Everett M. (1983) *Diffusion of Innovations*. 3. ed. New York, NY: Free Press [u.a.].
Roper, Stephen, and James H. Love (2018). "Knowledge Context, Learning and Innovation: An Integrating Framework." *Industry and Innovation* 25, no. 4: 339–64.
Rothaermel, Frank T., and Maria Tereza Alexandre (2008). "Ambidexterity in Technology Sourcing: The Moderating Role of Absorptive Capacity." *Organization Science* 20, no. 4: 759–80.
Rubalcaba, Luis, Jorge Gallego, and Pim Den Hertog. 2010. 'The Case of Market and System Failures in Services Innovation'. The Service Industries Journal 30 (4): 549–66.
Salter, Ammon J., and Ben R. Martin (2001). "The Economic Benefits of Publicly Funded Basic Research: A Critical Review." *Research Policy* 30, no. 3 (March 1, 2001): 509–32.
Schnabl, E. and Zenker, A., (2013). *Statistical classification of knowledge-intensive business services (KIBS) with NACE Rev. 2*. Karlsruhe: Fraunhofer ISI.
Seeber, Marco, Benedetto Lepori, Martina Montauti, Jürgen Enders, Harry de Boer, Elke Weyer, Ivar Bleiklie, et al. "(2015) European Universities as Complete Organizations? Understanding Identity, Hierarchy and Rationality in Public Organizations." *Public Management Review* 17, no. 10: 1444–74.
Shaw, B. (1995) *User/Supplier Links and Innovation*. Edward Elgar Publishing.
Shearmur, R. (2016). Why local development and local innovation are not the same thing: the uneven geographic distribution of innovation-related development. *Handbook on the Geographies of Innovation. Edward Elgar Publishing*, 432-446.
Spigel, B. (2017) "The Relational Organization of Entrepreneurial Ecosystems." *Entrepreneurship Theory and Practice* 41, no. 1: 49–72.
Stoneman, Paul. *Technological Diffusion and the Financial Environment*, 2001.
Tanner, A. N. (2014). Regional branching reconsidered: Emergence of the fuel cell industry in European regions. *Economic Geography*, *90*(4), 403-427.
Teece, David J. (2007) "Explicating Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance." *Strategic Management Journal* 28, no. 13: 1319–50.
Tether, Bruce S. (2002) "Who Co-Operates for Innovation, and Why: An Empirical Analysis." *Research Policy* 31, no. 6: 947–67.
The Oxford Handbook of Innovation. Oxford University Press, 2006. https://doi.org/10.1093/oxfordhb/9780199286805.001.0001.
Todorova, Gergana, and Boris Durisin. (2007) "Absorptive Capacity: Valuing a Reconceptualization." *Academy of Management Review* 32, no. 3: 774–86.
Uyarra, E. (2010). Conceptualizing the regional roles of universities, implications and contradictions. *European Planning Studies*, *18*(8), 1227-1246.
Uyarra, E., and Flanagan, K. (2010). From regional systems of innovation to regions as innovation policy spaces. *Environment and Planning C: Government and Policy*, *28*(4), 681-695.
Uyarra, E., and Flanagan, K. (2010). Understanding the innovation impacts of public procurement. *European Planning Studies*, *18*(1), 123-143.
Vergori, Anna Serena. (2014). 'Measuring Innovation in Services: The Role of Surveys'. The Service Industries Journal 34 (2): 145–61.
Veugelers, R., and Cassiman, B. (1999). "Make and Buy in Innovation Strategies: Evidence from Belgian Manufacturing Firms." *Research Policy* 28, no. 1: 63–80.
Walker, R. A. (2018). Pictures of a Gone City: Tech and the Dark Side of Prosperity in the San Francisco Bay Area (Spectre).
Walker, R. M., Damanpour, F., & Devece, C. A. (2010). Management innovation and organizational performance: The mediating effect of performance management. *Journal of Public Administration Research and Theory*, *21*(2), 367-386.
Youtie, J., & Shapira, P. (2008). Building an innovation hub: A case study of the transformation of university roles in regional technological and economic development. *Research policy*, *37*(8), 1188-1204.
Zukauskaite, Elena. (2012) "Innovation in Cultural Industries: The Role of University Links." *Innovation* 14, no. 3: 404–15.