Innovation Policy and Place: A Critical Assessment[1]

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[1] This paper is based on research supported by a grant from Research England (formerly HEFCE) to the University of Cambridge (code HEIF-NPIF-CSTI/Place). The contents of this paper do not represent the views of Research England or the University of Cambridge. An earlier version of this paper was presented at the 'Innovating Places: Investing in Local Research and Innovation to Build Local Industrial Capabilities to Enhance Local Economic Benefits' workshop held at Trinity Hall Cambridge in July 2018. I would like to thank the organisers and other participants for their comments. The usual disclaimer applies.

Abstract

Innovation policy has become an integral part of modern industrial policy. This paper considers the role of innovation and place through the lens of UK innovation policy. It argues that much of innovation policy is focused on the generation of innovations and not the diffusion and adoption of innovation throughout the economy. This focus will do little to slow or reverse regional diverges in economic performance. Innovation policy at the local level requires greater focus on innovation diffusion whilst adopting both a wider perspective to encompass the variety of innovation and a narrower perspective to focus on the specific innovation needs of individual regions or localities.

Introduction

A focus on innovation is now a central feature of the re-emergence of place-based industrial policy. Yet, much of the focus is narrowly confined, and potentially distorted, by messages coming from science and from economics. From science, the foci are investing resources in STEM (science, technology, engineering and mathematics) and improving the commercialisation of science through technology transfer (often through patents, licenses and spin-outs). From economics, the focus is on the operation of markets and thus the policy instruments required when markets may 'fail'. In the realm of innovation, private firms may not invest in a level of R&D that is socially optimal, therefore this 'failure' has to be rectified by government intervention through publicly funded R&D or subsidies or tax-breaks. Although science and R&D are important - they are only parts of the innovation process. It is important to stress three points. First, innovation take place within a multi-level system and a preoccupation with 'markets', where the price mechanism allocates scarce resources, may ignore the important links, connections and feedback loops within the system. Second, local innovation systems will vary and will reflect different structures and trajectories of development. Third, R&D and technology transfer tend to be associated with the generation of innovations and not the diffusion and adoption of innovation throughout the economy. Since the industrial revolution, the diffusion of innovation has had a much larger impact on economic growth than the generation of innovation as 'innovation-using sectors' are much larger than 'innovation-generating' sectors. During the Industrial Revolution it was not the invention of a 'wave of gadgets' that generated growth but it was the use of such gadgets – such as the steam engine being deployed in the factory system. Similarly, the largest impact of information communication technologies is not through invention but by use throughout the economy by businesses, individuals and governments.

This paper considers the innovation policy through the lens of policy initiatives in the UK including the latest turn of place-based innovation policy. This paper is organised as follows. Section 1 outlines the convincing but incomplete narrative of how innovation influences economic growth that primarily draws on lessons from economic and science. Section 2, summarises the recent evolution of innovation policy within the broader framework of industrial policy in the UK. Section 3 considers the limitations of modern innovation policy and argues for a greater emphasis on innovation diffusion. Section 4 considers the spatial aspects of innovation policy and argues for a broadening of perspective to encompass the varieties of innovation combined with a narrower perspective that focuses on the specific innovation needs of a region or local area. The final section concludes.

1. Innovation: the conventional narrative

Developments in science and technology are considered central to economic growth as shown in the contributions of Schumpeter (1947) and developments in neoclassical growth theory (Solow, 1956, and Romer, 1990). In conventional exogenous growth models, such as the Solow-Swan model (Solow, 1956; Swan, 1956), a permanent increase in per capita growth is only achievable through technological progress which is exogenous and so can be considered as 'manna from heaven' (Davenport, 1985, p.139). Simply, technology is determined by the ideas that are generated by scientific discovery which is not influenced by economic processes or incentives. Developments in neoclassical growth theory led to the development of endogenous growth models that suggested that economic growth is primarily endogenous and not determined by external factors (Romer, 1960). Some vintages of endogenous growth theory suggest that there are positive externalities or spillover effects of investments in technology or related areas. Thus, endogenous growth models suggest that policy can improve the growth rate of an economy if policy makers can identify the correct areas to support.

The rise of endogenous growth theory provided a rationale and a framework for growth policy. In the UK in 1994, the shadow Chancellor of the Exchequer stated that a Labour Government's economic approach would be rooted in 'post neoclassical endogenous growth theory' although it was unclear in what way the policy was 'post neo-classical' as opposed to neoclassical (Brown, 1994). Later, the leader of the Labour Party at the time (Tony Blair) provided a more pithy and more intelligible version when he said that his economic priorities were 'education, education, education' (Blair, 1996).

The pervasive influence of modern orthodox economics helped to provide an apparently compelling narrative on how to stimulate economic growth and productivity. The key driver is technology which depends on investment in R&D. And the private sector may not invest in R&D at a socially optimum rate as individual firms who may invest in R&D will not gain **all** the benefits of such investments as other firms may benefit from the new ideas that are generated. Economists focus on the operation of markets – and this is one case where markets 'fail' and this provides a justification to remedy the market failure by policies to stimulate R&D through Government expenditure, subsidies, tax incentives or other means (Crafts, 1996).

The simple but powerful narrative that emerges from orthodox economics has been reinforced by the influence of the science lobby in many countries. Within academia, there has been emergent divisions between disciplines with the notion that investment in the 'hard' sciences will deliver bigger 'impact' on the economy and the standard of living. According to the UK Government: 'At a time when the pace of scientific discovery and innovation is quickening across the world, the UK is fortunate to be a nation of science and technical progress. We have three of the world's top 10 universities, and 12 of the top 100. Of the G7 countries, the UK has the most productive science base and we rank first in many key global measures of research quality. These academic achievements have practical benefits for our economy, with firms investing into the UK to access our research.' (HM Government, 2017, p.25)

In 'The Two Cultures and the Scientific Revolution', C.P. Snow (1959) identified the emergence of two cultures within academia: one comprising scientists and the other Snow termed 'literary intellectuals'. Snow's view was that 'the former are in favour of social reform and progress through science, technology and industry' whereas intellectuals 'are 'natural Luddites' in their understanding of and sympathy for advanced industrial society' (Critchley, 2001, p. 49). The role of the 'scientists' informs much of the debate on how academia can boost growth with a focus on educating STEM (science, technology, engineering and mathematics) graduates; investing in science research through R&D and other mechanisms; and encouraging impact through the commercialisation of science often through technology transfer mechanisms such as patents, licenses and spin-outs.

The combination of a powerful science and economics lobbies has provided a convincing narrative which was (and is) politically convenient. It is a simple story which contains easily understandable links and processes. Furthermore, it is relatively uncontroversial as few object to supporting science and scientists. Moreover, it can be a relatively cheap way to accumulate political capital, with Government ministers being seen opening new laboratories or dressed in white lab coats conversing with scientists. The conventional wisdom is captured in the innovation policy framework in the UK: 'Our industrial strategy will launch a major upgrade in the role of science and innovation in our economy for the years ahead. It will build on our world-leading science base and hardwire innovation into our businesses, schools, workforce and individuals. We will: **Substantially increase investment in R&D and ensure that UK research continues to be world class'** (HM Government, 2017, bold in the original). Similarly, the EU has identified the following innovation challenges for the EU: '(1) lack of quality of the science base; (2) feeble contribution of the science base to the economy and society; and (3) inadequate framework conditions for business R&D and innovation (European Commission, 2014). And has identified the following policy priorities: 'The EU is implementing policies and programmes that support the development of innovation to increase investment in research and development, and to better convert research into improved goods, services, or processes for the market' (European Commission, online).

2. The innovation turn in industrial policy: addressing the productivity challenges

Innovation has been the prime long-term driver of economic growth since the industrial Revolution. The UK was the productivity leader in the mid-nineteenth century but since then other countries have caught up and may have surged ahead (Broadberry and Irwin, 2004). Figure 1 shows the productivity gap between the UK and many other advanced countries in 2015 and 2016. Figure 1, which is gross domestic product per worker in the G7 countries, shows that the UK had a significant gap with the rest of the G7 overall and with individual countries with the exceptions of Japan and Canada. Figure 2, which shows gross domestic product per hour worked in the G7, also shows a significant gap. The differences in the pattern of productivity between Figures 2 and 3 reflects differences in average hours worked across the countries. The productivity gap between the UK and the US is wider in terms of output per worker than in terms of output per hour because US workers work more hours than UK workers. Conversely, the productivity differential between the UK, and Germany and France is wider in terms of output per hour than in terms of output per worker, as German and French workers work fewer hours than their UK workers.

[Figures 1, 2 and 3 here]

Since the financial crisis and Great Recession there has been a slowdown in productivity growth in many advanced countries. Figure 3 shows the productivity slowdown in the G7 countries since the financial crisis which has been particularly stark in the UK. There has been considerable debate about the productivity slowdown or productivity paradox (see Crafts, 2018). There are three broad strands to this debate. First, that the slowdown is a mirage or artefact as national income accounts fail to capture the full impact of technological change especially in the digital age (Ahmad and Schreyer, 2016). Second, that the slowdown is a temporary phenomena. According to Moryr, there is no evidence of diminishing returns to technological progress, and 'science and technology's main function in history is to make taller and taller ladders to get to the higher-hanging fruits (and to plant new and possibly improved trees)' (OECD-NBER, 2014, p.6). Third, and most worryingly, the slowdown is a permanent phenomenon. Gordon has argued that the productivity slowdown reflects a lack of growth-enhancing innovations: recent General Purpose Technologies (GPT) such as ICT have less of impact on growth compared to previous GPTs such as electrification and the internal combustion engine (OECD-NBER, 2014, p.5).

The policy agenda to address the productivity challenges in the UK has waxed and waned over the past 20 years. The election of the Labour Government in 1997 saw a slight movement away from the free market policies of the previous Thatcher and Major Governments where industrial policy was castigated as 'picking-winners' and distorting the efficient operation of market forces. Labour adopted a 'third way' approach to productivity and identified five key drivers; skills, enterprise, innovation, competition and investment (Balls et al., 2004; HM Treasury, 2000; Kitson et al, 2004). The innovation driver aimed to promote 'world class science and innovation in the UK' and collectively the drivers aimed 'improve the economic performance of all English regions and reduce the gap in economic growth rates between regions (HM Treasury, 2007, p.242).

According to Cook et al (2018, p.5) productivity was at the 'apex of the policy narrative' between 1997 and 2010, and 2015 onwards. The lacunae followed the financial crises when the policy agenda was obsessed with austerity and fiscal retrenchment. It may also be the case, that productivity has fallen down the policy agenda since 2016 as policy has been hijacked by Brexit. Despite this, the UK Government has introduced a new industrial policy where productivity is placed centre stage. The strategy has identified five 'foundations of productivity': ideas, people, infrastructure, business environment and places (HM Government, 2017). The strategy has many similarities with Labour's five drivers: the 'ideas' foundation aims to make the UK the 'world's most innovative economy (HM Government, 2017, p.14) but 'place' is more centrally located as a foundation of productivity growth.

There are four key characteristics of the role of innovation in recent industrial policy. First, innovation is considered as one of the key drivers or foundations of productivity but it is important to emphasise that it is not the only driver – and the importance of individual drivers (and their interactions) may vary by place. Second, the focus of the innovation driver has focused on the development of new innovations from the science base. A consistent thread across the policy 'churn' has been the targeting and support of R&D and encouraging the commercialisation of science (Cook et al, 2018, p.15). More recent developments such as the establishment of intermediary institutions such as Catapults and the identification of 'grand challenges' support the development of new innovations and are not primarily concerned with diffusion. It should be noted that some policy documents promulgate a wider concept of innovation (see DIUS, 2008) but the reality of policy implementation is narrower, as a Parliamentary Select Committee inquiry observed: 'While the government's rhetoric marks a step change…the government's approach appears to be evolutionary' (BEIS Strategy Committee, 2017). Third, the institutional framework to support innovation has undergone regular shifts. The Labour Government regionalised some of the support for innovation including through the Regional Development Agencies (RDAs). The RDAs had teething problems when they were established, with one concern that they were engaged in place competition in innovation; but they developed their competences and maturity – and then they were scrapped. Following the abolition of the RDAs, innovation support programmes became more centralised through the Technology Strategy Board (later Innovate UK). Fourth, place is now identified as a central foundation of productivity. But applying an innovation policy that focuses on the generation of innovations may do little to improve regional growth and imbalances.

3. Limitations of modern innovation policy

A common focus of policy is to conflate technology with innovation. Technology is narrower concept than innovation which encompasses the technological aspects of products and processes. Whereas innovation – at its most basic is 'the successful exploitation of new ideas' (DIUS, 2008, 12). Innovation can vary in terms of products, services, processes and business models and occur in the private, public and third sectors (Christopherson et al, 2008). Yet, many policy initiatives concentrate support on the narrow aspects of technological innovation such as support for R&D and on support for technology transfer from universities.

The convenient target- the 'rhyming couplet' of R&D

One of the most pervasive tools to encourage innovation is support for R&D – including direct funding or incentives for the private sector to append on R&D. The UK public sector funds R&D in various departments and in other sectors of economy such as in the higher education sector (Hughes and Martin, 2012). In 2015, Government (including research councils) was the second largest sector of funding with £6.5 billion (21% of total UK R&D funding) (ONS, 2018a). This funding has various components but it is primarily focused on the generation of new technologies. The UK government has initiated an Industrial Strategy Challenge Fund to increase funding in research and development by £4.7 billion as part of a 'long-term plan to raise productivity and earning power in the UK' (UKRI, online). Fothergill et al have argued that the initiative 'is targeted at R&D in an exceptionally narrow range of sectors' that are 'truly at the most exotic, leading edge of technology' and that 'the list has been shaped by research scientists rather than by business leaders grappling with real-world pressures to design, produce and sell to the rest of the world (Fothergill et al, 2017, p.4). They argue that the sectors involved account for only around one per cent of the UK economy and that research activities are very unevenly spread across the UK (Fothergill et al, 2017).

Incentives for the private sector to increase R&D are usually through a 'tax credit' or an 'enhanced allowance' where the former reduces liability to corporation tax and the latter allows companies to deduct R&D expenditure from taxable income (Fowkes, Sousa and Duncan, 2015). According to survey by the European Commission (EU and other comparator countries) 21 of the 33 countries had a tax credit scheme and 16 had an enhanced allowance scheme (European Commission, 2014). The impact of R&D tax credits has provided mixed results (see Hall and Van Reenan 2000 and Becker, 2014). The European Commission reported that R&D tax credits are effective in stimulating investment in R&D but identified three important limitations to this conclusion (2014, p.5-6). First, the 'size of this effect are widely diverging and are not always comparable across countries due to differences in methodology'. Second, 'rigorous studies' show that foregone tax revenue due to tax incentives is higher than increased expenditure on R&D. Third, the impact of R&D tax incentives on innovation and productivity is not well studied.

One of the problems with studies that try to estimate the impact of incentives on R&D on R&D expenditures is that they are frequently based on data collected by tax authorities which may bias the data. If you ask those given tax benefits whether those benefits are working it is no surprise that the answers will be the affirmative particularly if there is flexibility in accounting practices that allows some reallocation of expenditures to the R&D category. The more important challenge is to identify an impact of R&D incentives on innovation activities (including products, processes and business models). A study by Kitson and Primost (2005) tracked the innovation activities of 21 firms in the British aerospace and biotechnology sectors. All the firms in this study identified R&D tax credits as a help to their activities but all indicated that it had **no** direct impact on their research and development activity. The benefit of the tax credit was that it improved cash-flow or it reduced the cash-burn rate but it had no direct impact on the decision to develop a technology or to increase R&D .

The conflation of R with D also masks many of the differences (albeit blurred differences) between the two concepts. Research is often divided between 'basic' and 'applied' which often does not take account of the interactions between research of different types. Stokes (1997) suggested an alternative framework where research was categorised as the pursuit of fundamental understanding (pure basic research) or solely with application (pure applied research) or with both (user-inspired research). Whichever formulation is preferred, research is part of the learning process whereas development is concerned with application of the research to provide functional use. It has been contended that the UK is strong in R but not in D. Haldane (2018b, p.7) has argued that: 'Typically, we think of 'Research and Development' (R&D) as a rhyming couplet. In the UK's case, the R and the D do not seem to rhyme. The UK does R well, as a world-leading innovation hub. But it does D poorly, where the D refers not just to development but the diffusion and dissemination of innovation to the long, lengthening, languishing lower tail. When it comes to innovation, the UK is a hub without spokes.'

Another concern with R&D incentives is that they are a tool that is narrowly focused on a small range of sectors and a small number of firms. According to EU R&D Scorecard: 'The top 2500 global R&D companies in the Scoreboard (all with R&D over €25m) account for approximately 90% of the world's business-funded R&D' (Hernández, 2018). Furthermore 'R&D is very concentrated with the top 10 companies contributing 15%, the top 50 40% and the top 100 53% of the total global 2500 R&D' (Hernández, 2018). In the UK, 75% of private R&D spending is concentrated in just 400 companies (HM Government, 2017).

This skewness is not surprising as R&D is a partial and incomplete indicator of innovation as many firms that do not engage in significant levels of R&D are still producing innovative outputs or engaged in other forms of innovative activity (Abreu et al, 2008a). Arundel et al (2007, p.3) observed that: 'R&D is not the only method of innovating. Other methods include technology adoption, incremental changes, imitation, and combining existing knowledge in new ways. With the possible exception of technology adoption, all of these methods require creative effort on the part of the firm's employees and consequently will develop the firm's in-house innovative capabilities. These capabilities are likely to lead to productivity improvements, improved competitiveness, and to new or improved products and processes that could be adopted by other firms. For these reasons, the activities of firms that innovate without performing R&D are of interest to policy.' They may be of 'interest to policy' but they are often marginalized or ignored. According to PwC (2017, p. 9) new forms of innovation 'such as open innovation, design thinking, and co-creation with partners, customers, and suppliers, are now all embraced ahead of traditional R&D, and by a wide margin— almost twice as many companies favor these models.'

It is important to emphasise that innovation is not solely the domain of high-technology manufacturing firms; it is also important in services as well as other mundane parts of the economy and often does not involve R&D. Evidence from the Community Innovation Survey shows that 50% of UK innovating firms conducted no R&D in 2006-08 (BIS, 2011, p.97). Abreu et al (2008b) identified high levels of 'hidden innovation' in the UK services sector but this innovation in services rarely depended on R&D. Innovative services firms were not developing new high-technology products but finding new solutions to their customers' problems or needs, which often did not involve technology. Arundel et al (2008, p.3) argue that 'non-R&D innovators are relatively more dependent than R&D performing firms on the diffusion of knowledge from other firms, particularly through knowledge embodied in acquired products and processes.'

Universities as sources of technology

Innovation policy in many advanced and emerging economies has increasingly focused on the strategic role of universities to increase the commercialization of science and the transfer of technology (Abbas et al, 2019; Kergroach et al 2018; OECD, 2013). This is illustrated by UK's policy framework.

> 'As well as increasing overall funding for research and development, the Government will continue to work with universities and research institutions to

> further improve the economic impact of research investment. We need to ensure that university spin-outs have the best chance to survive, attract investment and grow over the long term. With a view to spreading best practice the Government will commission research on different institutions' principles and practices on commercialisation of intellectual property, including how they approach licensing intellectual property and take equity in spin-outs.' (HM Government, 2017, p.32)

This focus is putting increasing pressure on universities to change strategy and put more resources into commercialisation. According to the Witty Review (2013, p.6):
'Universities should assume an explicit responsibility for facilitating economic growth, and all universities should have stronger incentives to embrace this "enhanced Third Mission" – from working together to develop and commercialise technologies which can win in international markets to partnering with innovative local Small and Medium Enterprises'.

Technology transfer is an important element of the knowledge exchange spectrum, but it is only one set of mechanisms through which universities influence innovation which is not prominently recognised in much of the policy discourse. (see Salter et al, 2000 and Hughes and Kitson, 2012).

The focus on the commercialisation of science and technology transfer is consistent with the convenient narrative that science is key to innovation. It is also useful as it provides a framework to capture metrics to judge the success (or impact) of universities. But reliance on measuring indicators of commercialisation such as patents, licences and spin-outs is flawed. As Goodhart (1981) observed: 'any observed statistical regularity will tend to collapse once pressure is placed upon it for control purposes.' Thus, metrics of commercialisation may be artificially inflated to improve the 'measured' impact of a university – simply, encouraging and promoting technology transfer when it may not be appropriate. Furthermore, although collaborations between universities and business includes technology transfer mechanisms it also includes more widespread knowledge exchange mechanisms which include people-based, problem-solving and community orientated activities (Hughes and Kitson, 2012). As Einstein allegedly observed: 'not everything that can be counted counts and not everything that counts can be counted' (attributed to Albert Einstein). Additionally, knowledge exchange is not restricted to STEM disciplines but includes academics from the arts and humanities and the social sciences (Lawson et al,2016). This reflects that businesses collaborate with academia not simply to develop new technologies but to improve wider innovation including processes and business practices. A study of the collaborative behaviour of UK business showed a wide range of motives including to support the introduction of a new product or a new process; to support service development; and to improve firms marketing and sales (Hughes and Kitson, 2013).

The focus on technology transfer is a partial and distortionary picture of knowledge exchange activities in the UK where there is a high degree of connectivity between the academic community and other parts of the economy. The developing requirement of universities to produce science that has impact may distort the broader contribution of universities. Haldane (2018a, p.21) has made the case to: '…….broaden the scope and purpose of universities. In future, these would develop a broader set of capitals – beyond human capital (in people) to include physical and intellectual capital (in firms). And they would do so throughout the lifecycle of companies, not just in their early years. As it happens, this would also be consistent with Newman's original conception of universities as diffusion-engines, every bit as much as innovation-engines.'

The focus on generation not diffusion
Much of innovation policy is concerned with the generation of new technologies but there is less focus on the diffusion and use of such technologies. The 'development' of new technologies itself has only small economic impact as technology-producing sectors are relatively small in terms of employment and as a share of national income (Christopherson et al, 2008). Thus, the creation of 'high-technology clusters' will, in most cases not have a major impact on local economies. The diffusion and use of technologies, however, does have the potential to have major impact on national and local economies. But such diffusion can be difficult, costly and take time; constraints that can be reduced by appropriate policy initiatives. One of the architects of modern growth theory that stressed the importance of technology observed in 1987 that: 'you can see the computer age everywhere but in the productivity statistics' (Solow, 1987). This was a period when ICT technologies were being developed but were not widely deployed through the US economy. By the mid-1990s, ICT technologies were widely deployed throughout the US economy and productivity was growing rapidly. And the sectors that were driving productivity growth were the innovation-using sectors which were also large in terms of employment or income shares. According to Solow (2001), the three industries which contributed most to the productivity surge in the USA from 1995 to 2000 were wholesale trade, retail trade and financial services.

An article in the New York Times in 2001 reported that 'Europeans assume that American growth is driven by Silicon Valley . . . That view is wrong.' (Postřel quoted by Freeman et al, 2011). Postrel focuses on productivity growth in the retail sector and argues that a sixth of that improvement is attributable to one company - Wal-Mart. Solow further commented on the US productivity surge: 'By far the most important factor in that is Wal-Mart….. That was not expected. The technology that went into what Wal-Mart did was not brand new and not especially at the technological frontiers, but when it was combined with the firm's managerial and organizational innovations, the impact was huge (quoted in Schräge, 2002). Furthermore, Solow argues that key factors are 'imitation, adaptation and organizational innovation that he believes traditional economists either minimize or ignore. Our historical research emphasis focusing on measuring R&D spending as a proxy for innovation is probably a mistake' (quoted in Schräge, 2002). This led Schräge (2002) to conclude that: 'This revolution…..reinforces a profound truth about the economics of innovation: implementation matters far more than invention.'

The importance (or implementation) of innovations requires understanding the specific environment and dynamics of each sector or region (McKinsey, 2002). In the UK, there is a range of evidence which shows slow and erratic diffusion of innovations. Evidence from the Community Innovation Survey shows relatively low rate of new products and process innovations (Eurostat). The adoption of advanced technologies is also erratic . The Bank of England has analysed the adoption rates of six technologies (mobile access to email, documents and software, websites with online ordering, fast broadband access and electronic data interchange sales) which shows 'a patchy picture of technological adoption among UK companies, with a long tail of slow-adopters of basic and especially advanced technologies' (Haldane, 2018b, p.10). In the service sector many businesses lack the skilled personnel or intelligence on markets and technology that would enable them to become more innovative (Abreu et al 2008b).

There are many different aspects of the diffusion of innovation but a common requirement is the effective movement and exchange of ideas and knowledge. This requires building connections to sources of ideas and expertise which requires investment - either in individuals who can develop and facilitate networks - or to build intermediary institutions. There has been many initiatives in this realm including the Catapult Programme in the UK which is based on the more extensive Fraunhofer Institutes in Germany. But these initiatives are primarily science-based and are to remedy limitations in the technology transfer process. They are not primarily concerned with the broader process of knowledge exchange or the more extensive need for the diffusion of innovations.

4. The Spatial Dimension

The focus on innovation is not simply a national phenomenon, it has acquired importance at the regional and local levels. In the UK, for example, the improvement of regional innovation has increasingly been highlighted as important for both regional and national economic growth (BEIS, 2017; BIS, 2011; HM Government, 2017). Similarly in the EU, there is greater focus on 'creating the eco-systems that encourage innovation, research and development (R&D) and entrepreneurship' (European Commission, online). Innovation is seen as crucial to improving local and regional productivity which in turn should increase national productivity. Of course, productivity is not the only target of economic policy but as Krugman observed: 'productivity isn't everything, but, in the long run, it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker' (Krugman, 1997, p.11). This of course, applies at the local and regional levels as well as the country level, and the 'standard of living in this context equates to higher real wages in addition to higher profits and tax revenue.

There are large and widening productivity variations across the regions in the UK (Kitson et al, 2004; Martin 2009). Figure 4 shows the regional variation in labour productivity (measured as gross value added per hour worked) in the UK in 2016. Only London and the South East (together sometimes called the Greater South East) had productivity above the UK average; with Wales and Northern Ireland having the lowest levels of labour productivity. Differences in labour productivity between regions may reflect structural differences and or firm-level differences. Some regions having a higher concentration of higher productivity sectors compared to other regions; whereas some regions may have similar industrial structures but there may be firm-level differences in productivity between regions. Analysis by the ONS (2017) has disaggregated the sources of regional productivity differences in non-financial businesses which are shown in Table 1. Column 1 shows the labour productivity index in the UK regions in 2014 (where the UK=100). Column 2 shows the firm productivity index which shows the average level of productivity in a region assuming the industry composition in that region is the same as for the national economy.

Column 3 shows the average level of productivity in a region assuming the productivity of each industry in that region is the same as nationwide average for that industry which shows the effect of industrial composition on the region's productivity. Column 4 shows a residual covariance term which reflects the interactions between the firm index and the industrial composition index.

[Figure 4 and Table 1 here]

Table 1 suggests that variations in firm level productivity help to explain much of the variations of regional productivity. For instance, firm level productivity in London (the highest region) is more than twice that of that in Wales (the lowest region). The industry composition index explains much less of regional variation in productivity. For instance, industrial composition in Scotland (the highest region) is only 14% higher than that in South West the lowest region). Overall, the ONS data suggests industrial composition is not a major explanation of regional productivity differences. It is firm level variations that help to explain much of regional variation in productivity. But a note of caution is there may be a significant variation in the operations and activities of firms that are designated as being in the same industry.

Further analysis of firm level variations in productivity is shown in Figure 5 which shows the productivity distribution of UK firms compared to French and German firms (Haldane, 2018b). There is a higher share of UK firms in the upper tail compared to French and German firms but there is smaller share in the middle and a much bigger share (a fat tail) in the lower end of the distribution. According to Haldane (2018b): 'the UK is in many respects a tale (tail) of two companies: a small set in the upper tail gazelling along the productivity high road and a much larger set in the lower tail snailing along the low road' (p. 4). Furthermore, Haldane (2018b) argues that the fat tail of companies are spread across the regions of the UK and that they operate significantly below the technological frontier of the leading firms and this can help to explain the productivity slowdown in the UK.

[Figure 5 here]

In the UK, the recent emphasis on improving regional innovation reflects both the application of the conventional innovation narrative to different spatial levels combined with the concern that national innovation policies may exacerbate regional disparities. Howells (2005) has observed that a 'top-down' national innovation policy that focuses on R&D may benefit relation successful core regions whereas disadvantaged regions will benefit least. Furthermore, Oughton et al (2002) have identified a 'regional innovation paradox', whereby lagging regions may not benefit from policy interventions as they have a relatively low capacity to absorb innovation funds compared to more advanced regions.

The argument that increasing R&D in lagging regions will substantially boost regional (and national) growth and productivity is a seemingly plausible local dimension of the pre-eminence of science-innovation narrative. In the UK, a common component of this narrative is to plot R&D intensity against regional GDP which displays a positive correlation. The correlation is weak and London does not fit the story but that does not stop correlation being assumed to be causation, leading to clarion calls for support R&D in the lagging regions. According to Forth (2018), 'R&D investment seems to be one of the few ways of boosting underperforming regions that works in the long-term.' Similarly, Jones (2018) has argued: 'There's one factor that, unless urgently addressed, will hold UKRI back from its mission of making a significant difference to the UK's overall productivity problems and raising the economy's R&D intensity. That is the extraordinary and unhealthy concentration of publicly funded R&D in a relatively small part of the country – London, the Southeast, and East Anglia.' Yet, it is questionable whether differences in R&D intensities are 'extraordinary', 'unhealthy' or are holding back the UK's overall productivity problem.

Application of the science-innovation narrative is now part of place-based policy. The UK Prime Minister declaimed: 'Our challenge as a nation, and my determination as Prime Minister, is not just to lead the world in the 4th industrial revolution – but to ensure that every part of our country powers that success. That is what our modern Industrial Strategy is all about' (May, 2018). According to HM Government (2017, p15): 'there are regional disparities in how the public sector and companies spend money on research and innovation, with UK public R&D funding heavily focused on the 'golden triangle' of Oxford, Cambridge and London. As well as continuing to unleash the excellence of institutions, we need to build on the excellence in research and innovation that exists in other parts of the country too, and ensure that capital, institutional influence and government attention is targeted there effectively.' In the UK, the proposal is to create competitive funding streams to support clusters of research and innovation in all parts of the UK.' (HM Government, 2017, p.115)

The rhetoric has been strong but this strength is not apparent in the delivery and funding of policy – which may reflect pressures on public spending due to austerity and Brexit-induced torpor in policy making . The UK government has announced that it is 'launching a new competitive £115m Strength in Places Fund to support areas to build on their science and innovation strengths….. The fund will support collaborative programmes based on research and innovation excellence in places right across the UK which can demonstrate a strong impact on local productivity.' (HM Government, 2017, p. 85). Funding at level allocated will do little to address the spatial disparities in R&D funding across the UK but will provide the opportunity to undertake some policy experiments. The aim of the Fund is to identify and support areas of emerging R&D strength that will lead to stronger business clusters' (Centre for Cities, 2018, p.4). The Fund is targeted at those businesses and research organisations at, or near to the frontier of the economy; and so will do little to directly promote innovation in lagging sectors and firms.

Universities are also part of the regional application of the science-innovation narrative. The national agenda is that there is 'potential for universities to generate even greater economic value from research, for example through intellectual property licensing and spin out businesses' (HM Government, 2017, p.171) and in addition ''innovation clusters' will form and grow around our universities and research organisations, bringing together world-class research, business expertise and entrepreneurial drive. These clusters can create thousands of skilled jobs in R&D, innovation and wider sectors, driven by the growth in science, technology, engineering and maths (STEM) skills' (HM Government, 2017, p.67).

The limitations of conventional spatial innovation policies

Innovation should not be considered as a panacea for regional imbalances. In some cases regional policy might be best to focus on more mundane but more effective interventions such as improvements to transport and investments in human capital. Furthermore, it is important to note that the drivers or foundations of regional competitiveness are interdependent; and increased innovation normally requires investment in complementary assets such as capital goods or skills. One additional problem with the application of conventional science-innovation policies to regions or cities is that the approach is too narrow for the requirements of many places. Conventional policy focuses on the productions of innovations rather than their diffusion and innovation-producing sectors are relatively small and will contribute little to most local economies. This is illustrated by Sir Paul Nurse's observations on the UK Government's investment in a graphene centre in Manchester. 'It simply looked good, because you had the Nobel prize for graphene and people said, "Excellent. Let's now invest in graphene."….. It is not a bad thing to do, but the decision to do it should take a much wider perspective than simply having a couple of really excellent scientists. You have to think about all the surroundings. Maybe that is there in Manchester, but it needs to be factored into the decision making—not just the fact that you have a couple of Nobel laureates there' (Nurse, 2018). Furthermore, as many innovation generating places exploit the benefits of agglomeration, spatial 'jam spreading' may weaken national innovation capabilities.

A second problem of 'universalism' of policies, where it is assumed that similar policies will have a similar impact in different places (Kitson et al , 2004). As noted above there are differences between R and D and the distribution is highly skewed across sectors – this has a spatial dimension reflecting the multifaceted regional 'faces' of R&D (Wintjes and Hollanders 2010). Variations in industrial structure and economic geography will have a major influence on the impact of policy. Thus, investing in innovation may have beneficial effects in some regions but not in others. As Oughton et al (2002) have identified, there may be significant variations in the absorptive capacity of regions to utilise innovation polices. Abreu et al (2008a) argue that differences in firms' absorptive capacity are due to sectoral and technological specificities which differ across regions.

In the case of the contributions of universities, it is important to acknowledge the contrasting roles that individual universities play in their local and regional economies (Asheim and Gertler, 2005). They will reflect the various strengths of different universities and the extent to which they are embedded in the local, national and international economies (Lawson et al, 2018). Furthermore, the focus on technology transfer ignores the potential for academia to engage to improve wider innovation, including in established larger firms and in traditional industries.

An alternative approach to spatial innovation policies

Innovation policy at the local level requires a both a wider perspective to encompass both the varieties of innovation and the variety of features of an innovation system; and a narrower perspective to focus on the specific innovation needs of a region or local area. In particular there needs to be great focus on the diffusion and use of innovations – including those innovations that were developed elsewhere – nationally and internationally.

Improved diffusion of innovation for some sectors of the economy requires national initiatives – retail, wholesale and transport facing similar innovation challenges in different places. Other sectors have innovation needs which reflect the economic geography and economic structure of the local economy. Policy needs will be shaped by the specific characteristics of the local economy and similar policy interventions may lead to very different impacts in different places but there are some common requirements. First, innovation and innovation diffusion can benefit all sectors and firms – not just 'high technology' businesses or firms on the innovation frontier. Second, building networks that facilitate knowledge exchange to improve the diffusion of innovation that is appropriate for the local economy. Third, focus should be on long-term impact and policy should not shift based on short-term changes or temporary shocks. Metrics should not narrowly focus on hard economic indicators (such as GVA, patents etc) but should also include innovation trajectories and behavioural change which will provide better evidence of the long-term path of development.

Although there are commonalities, the innovation requirements of different places will vary. Lester's (2005) analysis of 22 regional economies from around the world provides a typology of the spatial variations of economic transformation processes delineating four processes: new firm formation; inward investment; diversification; and economic upgrading. First, indigenous creation, the process that is commonly associated with the generation of new ideas and conventional innovation policies including support for R&D and the focus on technology transfer from universities. Well known examples include the computer and information technologies around Silicon Valley and the software, electronics and biotechnology industries in Cambridge (Segal Quince Wicksteed, 1985). These high-technology clusters are an important part of the innovation system but they are not the panacea for economic prosperity in most localities as such activities form a relatively small share of national economic activity (Fothergill et al, 2017). Second, inward investment which involves the movement of businesses into the area. This may require the development of new supply chain and new clusters may develop (Tödtling-Schönhofer and Davies, 2013). For instance, the arrival of Nissan in Sunderland led to the development of a local supply chain and links with further education and higher education establishments to improve access to skilled labour. Third, diversification is a process whereby an existing industry in a region may be in decline but its core capabilities are redeployed or transformed to encourage the emergence of a new industry. This may require developments in products, processes and business models which require the use of and deployment of existing innovations. The development of a medical instrumentation industry in Sheffield reflects the legacy of the iron and steel industry. Fourth, industrial upgrading which requires the deployment of product, process and business model innovations to exiting sectors. The redevelopment of Manchester has included the upgrading of the city centre to improve access to public spaces and consumer services. The development of East Manchester is a successful redevelopment of derelict land to provide new sports facilities as well as space for residential and commercial uses.

The above is a simple taxonomy, and multiple processes may be operating in one place at any one time, but it illustrates that the 'skills, resources and institutional capabilities associated with each type of transition are different' (Lester, 2005, p.20). Furthermore, the requirements of all the processes - especially inward investment, diversification and upgrading - require the ability to connect and absorb innovations. This, in turn, will depend on the connective capacity and absorptive capacity of individual firms but it will also depend on the strengths of local networks to enable knowledge exchange. Such networks should be outward looking, connecting to local, national and global sources of innovation which are appropriate for the local economy and which 'ensure variety and new innovation impulses' (Tödtling-Schönhofer and Davies, 2013, p.20). Connecting to sources of ideas and innovations is difficult for many firms - particularly SMEs which often lack the information about how to collaborate and lack the resources to implement and manage connections (Hughes and Kitson, 2013). Building local networks requires investment in intermediary institutions with skilled staff who understand the needs of the local economy and its transformation pathways.

The role of local economic anchors, such as universities, will vary depending on the transformation pathway. Whereas indigenous creation is often associated with technology transfer from universities; inward investment may require a greater focus on skills and education; diversification may require the cultivation of 'technological links between disconnected actors' (Lester, 2015, p,27); and upgrading may require more problem-solving activities (Hughes and Kitson, 2013 and Lester, 2015). Rebalancing the impact of universities from 'technology transfer' to 'knowledge exchange' and broadening the innovation agenda to include innovation diffusion in addition to innovation creation may require a re-purposing of the university sector. Haldane (2018a, p.21), has argued that there is a need to '…….broaden the scope and purpose of universities. In future, these would develop a broader set of capitals – beyond human capital (in people) to include physical and intellectual capital (in firms). And they would do so throughout the lifecycle of companies, not just in their early years. As it happens, this would also be consistent with Newman's original conception of universities as diffusion-engines, every bit as much as innovation-engines.' Furthermore, universities can utilise their roles as economic anchors (they rarely move) and connectors to act as 'innovation bridges' to help local firms access ideas and innovation from outside the region or locality

Conclusion

Innovation policy at the local level requires both a wider perspective to encompass the variety of features of an innovation system; and a narrower perspective to focus on the specific innovation needs of a region or local area. This suggests seven key features of local-based innovation policy. First, the generation of innovations will not have a major impact on many local economies and thus science policy should not become an arm of local development policy. There is the risk of a 'white coat syndrome' where investment in science is considered essential to raising the pace of local economic development despite the relatively small number employed in pursuing scientific developments and the risk that the spatial spreading of scientific endeavours may undermine agglomeration benefits. Second, there should be increased focus on the diffusion of innovations; diffusion is costly and difficult and requires better knowledge exchange and boundary spanning skills. There are sectors that comprise a large share of both national and local economies where the diffusion of innovations should be improved at a national level such as retail, wholesale trade, transport and logistics. Third, however, the diffusion of innovations will also be partly contingent on the structural specificity and specific needs of the local economy. The innovation needs of a local economy will vary according to the process of economic development including: new firm formation; inward investment; diversification; and economic upgrading. Fourth, the diffusion of innovations should include: process, design, business innovations and should penetrate all sectors including ‘traditional sectors’. Fifth, connectivity with local economic ‘anchors’, such as universities and hospitals should be strengthened. Such anchors are often considered as ‘innovation-generating’ institutions; but they are also employers that do not tend to move and act as important sources of resilience. Also, they are sources of knowledge and expertise that enhance the diffusion and adoption of innovations. Sixth, connectivity and collaboration may require the development of new local structures that align the interests and coordinate the activities of actors in the local innovation system including businesses, universities and government. Seventh, is the need for policy stability and appropriate metrics. Focus should be on long-term impact and policy should not shift based on short-term changes or temporary shocks; metrics should not narrowly focus on hard economic indicators but should also include innovation trajectories and behavioural change which will provide better evidence of the long-term path of transformation and development.

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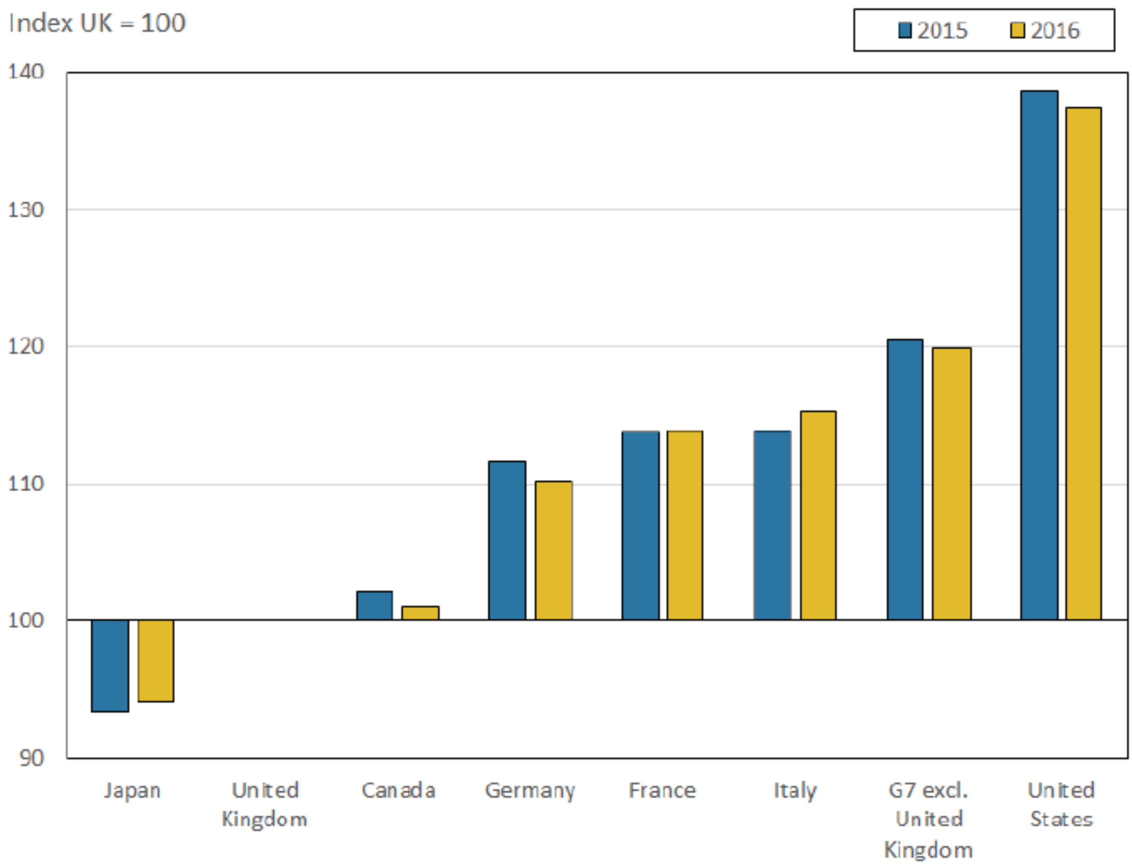
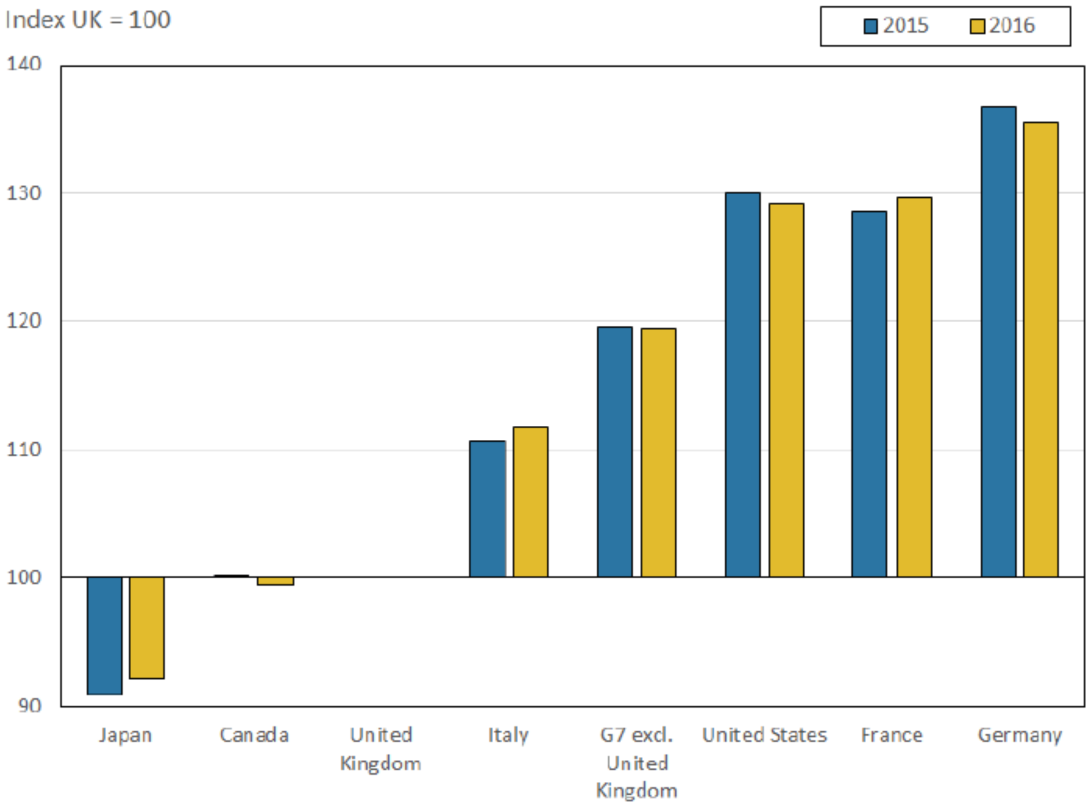
Tables and Figures

Figure 1. The international productivity gap: gross domestic product per worker, G7 countries



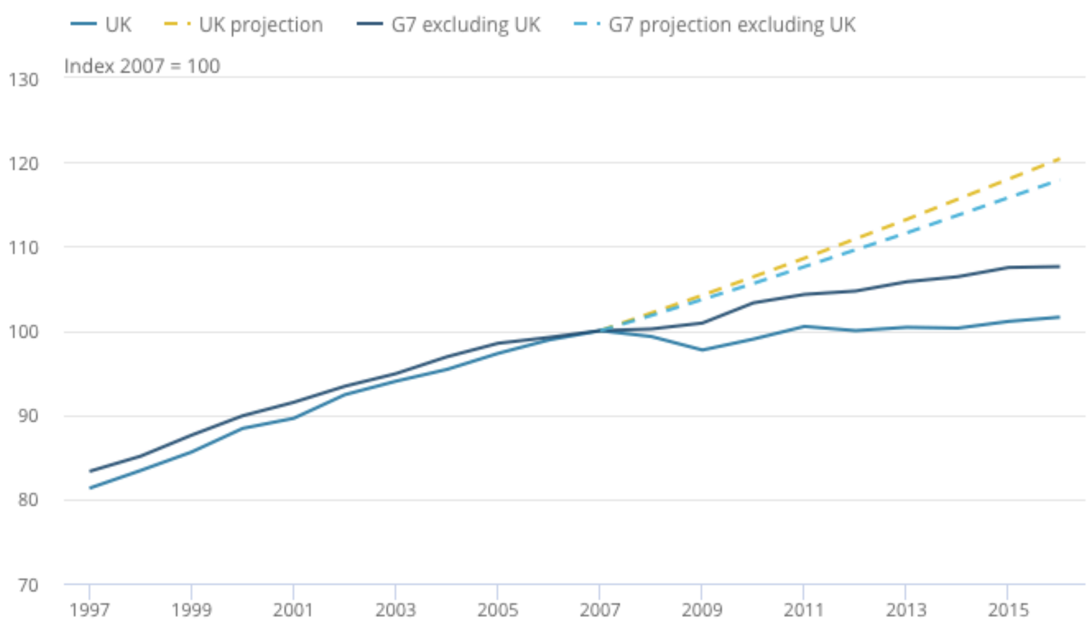
Source: ONS (2018b), International comparisons of UK productivity (ICP), first estimates: 2016, Statistical Bulletin, ONS, London, p.5

Figure 2. The international productivity gap: gross domestic product per hour worked, G7 countries



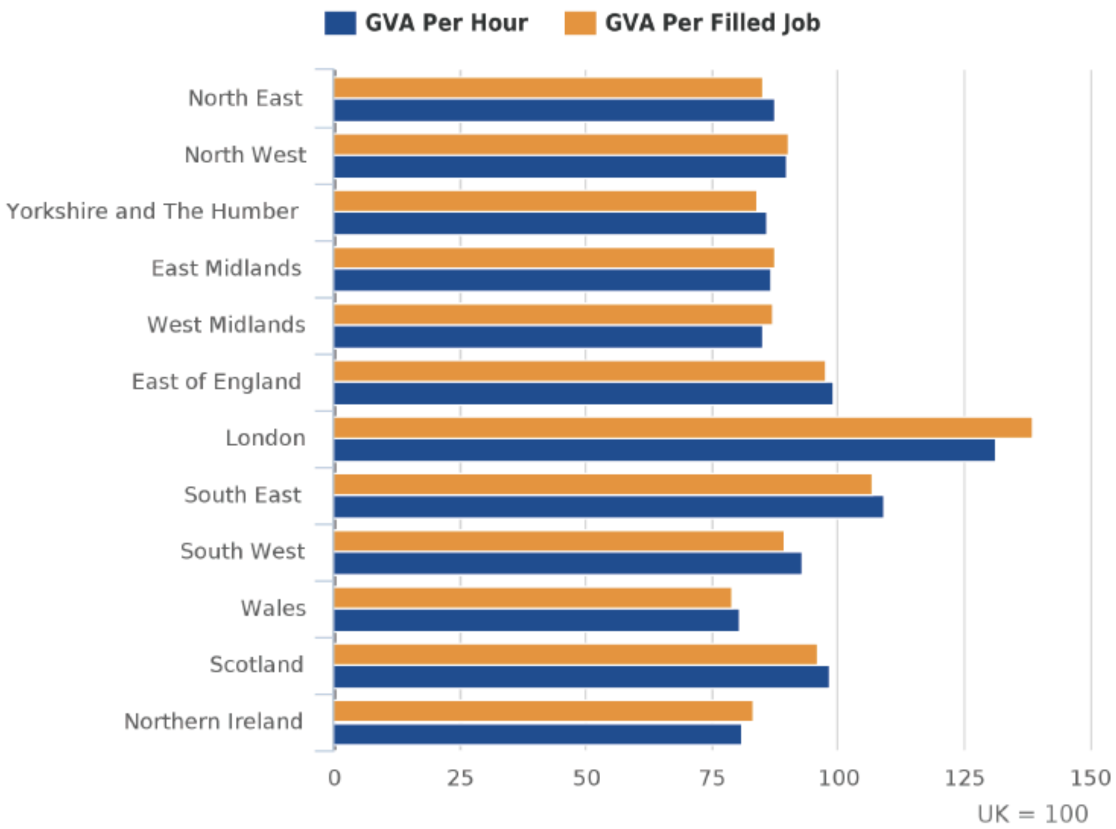
Source: ONS (2018b), International comparisons of UK productivity (ICP), first estimates: 2016, Statistical Bulletin, ONS, London, p.3.

Figure 3 The productivity slowdown: gross domestic product per hour worked, actual and projections (constant prices, UK and G7)



Source: ONS (2018b), International comparisons of UK productivity (ICP), first estimates: 2016, Statistical Bulletin, ONS, London, p.6

Figure 4 The regional gap: labour productivity in the UK (NUTS 1 region or country, 2015)



Source: ONS (2017a), Regional and sub-regional productivity in the UK: Jan 2017, ONS, London, p. 4.

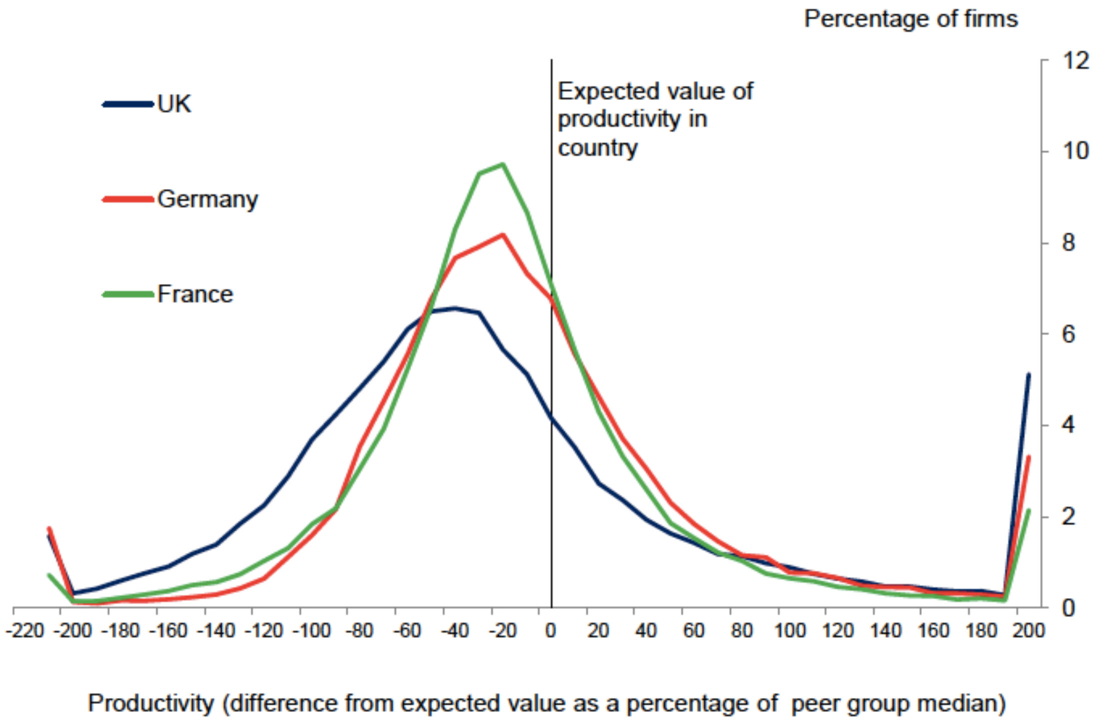
Table 1: Sources of Aggregate Labour Productivity (GVA per worker) 2014 - NUTS1 Regions (GB=100)

Region	Aggregate Average Labour Productivity	Firm Productivity Index	Industry Composition Index	Residual Covariance	Aggregate Average Labour Productivity, Great Britain
North East	84	89	100	-6	100
North West	91	96	97	-2	100
Yorkshire and The Humber	75	77	98	1	100
East Midlands	82	83	100	0	100
West Midlands	86	84	104	-1	100
East of England	89	93	97	-1	100
London	154	154	102	-2	100
South East	107	104	102	1	100
South West	78	82	95	2	100
Wales	72	72	96	4	100
Scotland	101	92	108	2	100

Source: Annual Business Survey (ABS) 2014, Business Register and Employment Survey (BRES), Inter Departmental Business Register (IDBR) – Office for National Statistics

Source: ONS (2017b) Regional firm-level productivity analysis for the non-financial business economy, p.10

Figure 5. The corporate gap: UK, Germany and France firm-level productivity (2013)



Source: Haldane, A. (2018b), The UK's Productivity Problem: Hub No Spokes, Academy of Social Sciences Annual Lecture, London , 28 June 2018

Note Estimated GVA (EBIT + employee costs) is regressed on a range of variables to control for sub-sector and number of employees using a Weighted Least Squares method (with employee numbers as the weighting). The output of this regression is used to compute an expected productivity, representing the average for a firm of that size in that sub-sector. The residual for each firm is plotted as a percentage of the median productivity for a firm in the same size bracket in the same sub-sector.