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BIG INNOVATION CENTRE

Making the UK a Global Innovation Hub

How business, finance and an enterprising state can transform the UK

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The Big Innovation Centre is an initiative of The Work Foundation and Lancaster University. Launched in September 2011, it brings together a range of companies, trusts, universities and public bodies to research and propose practical reforms with the ambition of making the UK a global open innovation hub as part of the urgent task of rebalancing and growing the UK economy, and with the vision of building a world-class innovation and investment ecosystem by 2025.

For further details, please visit www.biginnovationcentre.com

Executive summary

The UK economy confronts profound challenges and perhaps years of historically low growth. Yet there is also enormous opportunity. The pace of scientific and technological advance is accelerating; in particular, there are likely to be as many transformative so-called general purpose technologies introduced in the 21st century as over the past 500 years. Examples of general purpose technologies from the past and present include printing, steam power, electrification, the Internet and many others. The new sources of economic growth and jobs in the future must come from boosting the economy's ability to take full advantage of these technologies – the digital and low carbon economy, life sciences and health economics, and in other areas impossible to predict but which will surprise us – that underpin current and future innovation waves. General purpose technologies are the ultimate in economic creative destruction – they create and destroy industries and business models, remake markets and our lives, and they overturn the established corporate order.

The UK must develop a fully functioning innovation and investment ecosystem over the next 15 years to seize the opportunity of exploiting this new wave of useful knowledge. Periods of economic stress are not naturally associated with booms in innovative activity. The task now is to create a network of institutions, processes and methodologies that will spur both the magic of innovation and the tough task of its development and commercialisation. The private sector cannot shoulder the unknowable risks associated with the wholesale rebasing of the UK economy nor develop the appropriate architecture and networks alone. This requires the ongoing engagement of an enterprising state, harnessing the creative ability of both the private and public sector through open innovation. This cannot be done piecemeal. Britain needs to own this agenda and think big.

Innovation does not take place in an institutional vacuum. It involves a complex web of technologists and scientists, businesses, finance, demand (consumers), universities, skilled workers, public agencies, government and other institutions that interact in innumerable different ways. To build an effective innovation and investment ecosystem, there has to be a judicious mix of such agents keeping the flow of discovery and information open. Markets and communities where technology and knowledge are shared need to work, whether the ideas are protected by patent and copyright, or more freely available. The focus of economic policy should be on putting in place the conditions and frameworks that enable UK businesses to be the most innovative on earth, and make Britain a global hub for innovation.

The Big Innovation Centre subscribes to the view that the competitiveness and economic performance of firms, regions and nations still has to be understood in a local context. This is not despite, but because of the globalisation of production, trade and labour

mobility – the growth of trans-national corporations, information and communication advancements and the emergence of the e-business. These globalisation forces do not wipe out the role of local business networks or the nation state, but they reinforce their importance, due to fewer impediments to trade to shelter uncompetitive domestic firms and industries. Thus, differences in national institutions, economic structures, people, values, and histories contribute profoundly to competitive success.

Whether they realise it or not, the directors of leading companies look closely at the innovation and investment ecosystems of different countries when they make decisions about where to invest and create jobs. In response, policy makers should aim to make the UK's innovation ecosystem so attractive that the UK becomes a key global innovation hub where talent is fostered and investment is located, spurring economic growth, prosperity and job creation. This requires a radical shift in our approach to economic policy, not just from the government but from the world of business, finance and our knowledge institutions too.

Moving to this ecosystem approach is not the sole responsibility of the state – it requires collaboration between all agents – but the state is best placed to take the lead. The state should begin by rethinking its role as a funder and investor in the economy, and view itself more as an entrepreneur that invests to put in place the conditions in which innovative businesses can flourish in various areas. The Enterprising State needs to build a durable framework for long term public action and incentives for private action to bring this about.

The shift to an ecosystems approach to innovation must begin with an analysis of where failures in our ecosystem occur, and a comprehensive evaluation of current policies to examine whether they address the right failures in the right way. Then we need to set out a framework plan for innovation and investment to drive growth across the UK economy. Our first ideas for what could be done are set out below.

The ecosystem approach – towards a public policy agenda

- Private and public organisations should think and act in terms of how they fit into the innovation ecosystem – requiring an ongoing mapping and evaluation of capabilities and shortcomings but also of successes and opportunities;
- Build the Technology Strategy Board (TSB) into the world's most effective funder of catalytic research into the development and application of general purpose technologies (GPTs) both to individual companies but also networks of companies;

- Aim to have the globally most sophisticated national network of technology and innovation centres (TICs) organised as far as possible on open innovation principles and committed to supporting open innovation business models. As a first step bring forward the next wave of TICs, matching funding of £200m announced in Budget 2010;
- Co-develop with Britain's financial institutions a transformative structural shift in the supply of equity and loan finance to support innovative small and medium-sized enterprises (SMEs) in all regions and sectors
- Bring forward the planned launch of the Green Investment Bank, and significantly increase its capital:
- Develop the Business Growth Fund into a modern version of the 3iGroup with capital of at least £10bn;
- Pledge to restore investment in the physical and digital infrastructure, focusing in particular on improving communications and facilitating the growth of innovative firms;
- Ensure access to high quality broadband service at low costs for all households and businesses, to increase the social and economic benefits from broadband use throughout the digital economy;
- Give the Regional Growth Fund an explicit innovation-supporting funding stream, matching previous spending of £400m undertaken by Regional Development Agencies (RDAs), and build a capability to do this in every English region along with the existing capability in Scotland and Wales;
- Develop new incentives and frameworks to stimulate the demand side from business for both technological and non-technological knowledge transfer from universities and other public research organisations;
- Require the TICs to establish knowledge transfer networks for open innovation business models;
- Revolutionise Britain's system of engineering and scientific training and apprenticeship, beginning with UKCES identifying what mix of high level and technical skills will best support the exploitation of the next innovation wave;

- Develop ownership structures that support shareholder responsibilities as trustees for long term growth. As a first step we should examine the feasibility of a specific requirement to consider the impact on innovation as part of the public interest aspect of take-overs and mergers;
- A key objective for public procurement, regulation and standards setting must be to enable and drive innovation across the economy and in key growth areas (such as the low carbon and digital economies and the life sciences);
- Build innovation impact into reviews of regulatory requirements and standards setting to help encourage the adoption of cutting edge technology, especially in the vital high tech manufacturing sector;
- Above all, understand that all these proposals reinforce each other. To think in ecosystem terms requires an embrace of the new openness, a celebration of scientific and technological possibility and a passion to make and produce. What will underpin the ecosystem approach is a reinvention of the spirit that animated the Industrial Revolution – the quest for useful knowledge for human betterment.

'The sovereignty of man lieth hid in knowledge.. now we govern nature in opinions but we are thrall unto her in necessity; but if we could be led by her in invention, we should command her in action'.

Sir Francis Bacon 1592

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Chapter 1 The big economic challenges

The UK economy has suffered a permanent 'scar' equivalent to 4 per cent of GDP as a result of the recession, according to the independent National Institute for Economic and Social Research (NIESR). The UK is not expected to regain pre-recession levels of output until 2013, and is on course to have one of the slowest recovery periods on record according to the Institute – even worse than the Great Recession of 1930-1934.

But the overall macro position is accompanied by major structural challenges that must also be addressed. A key question has been how to rebalance the economy away from an overdependence on growth of the public sector in much of northern and midland Britain; towards manufacturing and away from some types of excessively risky financial services; and towards exports and investment in productive capacity and away from debt supported consumption and property speculation. Rebalancing the economy along any of these axes has proved challenging.

One illustration of the magnitude of the task has been the steady emergence of an underlying structural trade deficit as the UK moves from being a net energy exporter to a net energy importer. The underlying structural deficit may reach nearly 5 per cent of GDP by 2025 according to one forecast.[1] The deficit is likely to be disguised by improvements in the UK's current balance, which takes into account income from overseas assets, but it nonetheless signals an underlying competitive weakness that the temporary boost from the devaluation of the pound will not address.

At the same time, Britain faces a long process of 'deleveraging' as debt is reduced. Moreover, deleveraging is not just a problem for the UK, but is happening simultaneously in several OECD economies. In 2008 the total UK debt (private and public) was 470 per cent of GDP, compared with 340 per cent in Spain, around 300 per cent in France, Italy and the US, and between 250 and 270 per cent in Germany and Canada. Only Japan approached UK levels.[2] A recent estimate[3] put UK debt (private and public) at nearly 500 per cent of GDP in 2010 compared with between 300 and 400 per cent in France and Spain and less than 300 per cent in the US and Germany. But public sector debt in the UK is around 70 per cent of GDP. The UK's debt problem remains overwhelming a private sector problem.

1 Coutts and Rowthorn (2010) Prospects for the UK Balance of Payments. London: CBR Research Programme on Enterprise and Innovation

2 McKinsey Global Institute (2010) Debt and deleveraging: The global credit bubble and its economic consequences The Global Institute argue that the UK's overall position is overstated somewhat by its position as a global financial hub and taking this into account would have reduced UK total debt to 380 per cent of GDP.

3 Economist July 2011

The UK labour market has done remarkably well over the recession and in the first stages of the recovery. Employers in the UK have 'hoarded' labour, resulting in more jobs but very weak productivity growth. Even when stronger overall economic growth returns, the recovery could be productivity poor. Moreover, the latest figures show unemployment has started to increase once more. Bringing unemployment back to pre-recession levels is certainly achievable, despite the predicted loss of public sector jobs – but only if we have a strong and sustained private sector recovery.

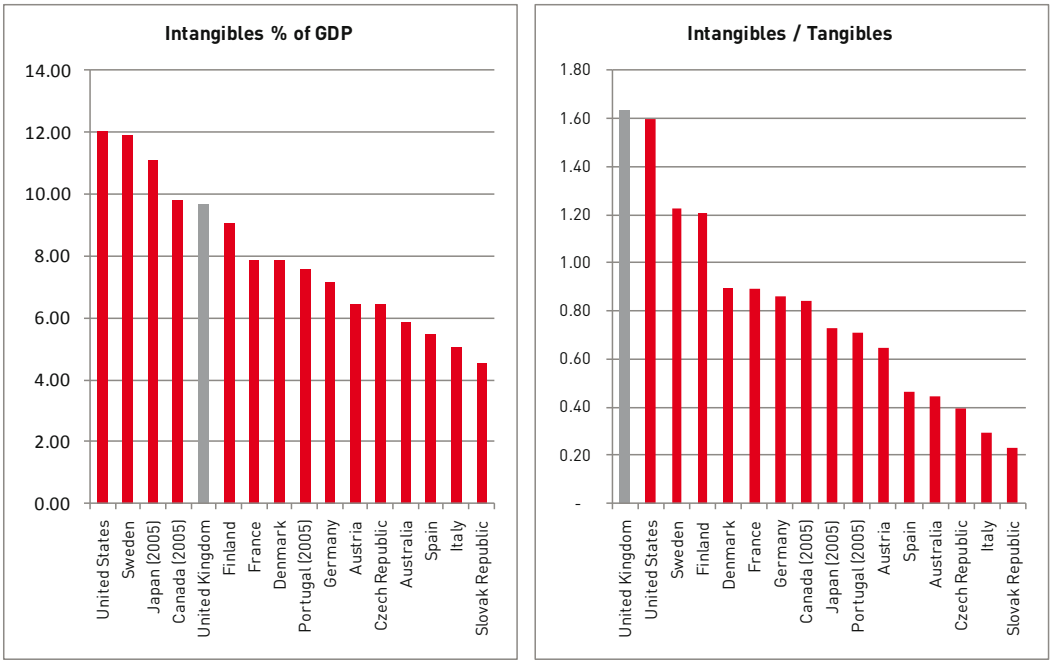
Even if the national picture improves, the UK faces significant regional and sub-regional challenges. Large parts of the country were dependent on public sector job growth in the decade before the recession. Over time areas with strong private sectors will over time successfully cope with the loss of public sector jobs. Areas with weak private sectors will struggle. These are the areas where underlying structural problems associated with the 'scarring' effects of long term unemployment – especially for the young – are most intense.

The economic debate is dominated by the balance between monetary policy and fiscal policy. The debt and deficit reduction programmes sometimes give the impression of becoming an inflexible end in themselves. None of these macro-economic policies alone offer a solution to the structural challenges facing the UK. Those solutions must be centred on increasing the pace and effectiveness of innovation and investment. That in turn cannot be achieved without a systems based approach – an innovation ecosystem approach.

The structural changes in our economy over the past 30 years also provide the potential solution to these major challenges. In common with most of the rest of the OECD, we have become a knowledge based economy – where competitive advantage is dependent on the effective exploitation of 'intangible' knowledge based assets such as design, software, human capital, brand equity, as well as R&D. Measured by business investment, the UK compares well against most other OECD economies and investment in intangibles now exceeds investment in physical infrastructure.

This is nowhere more important than in modern manufacturing where investment in intangibles exceeds investment in physical equipment by two to one. A key part of economic rebalancing will be to grow the UK's high tech manufacturing sector and, as we show later, the sector will be a critical driver in many of our innovation growth areas.

Figure 1: Business investment in intangible knowledge based assets across the OECD



Source: OECD (2010) Measuring Innovation: A New Perspective. 2006 data except where stated

Note: all figures share of market sector GDP. Finland excludes financial sector, US excludes farming. US average of 1998-2000; UK, Germany, France, Italy, Spain are 2004; Japan average of 2000-2005; Netherlands and Canada 2005. Source: Australian Productivity Council 2009

The shift in business investment has been accompanied by a change in the focus on job generation in the economy. In both previous post recession recoveries, some of the strongest areas of job generation were in knowledge and technology intensive industries – defined by the EU as including high and medium tech manufacturing; scientific, professional and technical services, financial services, creative services, and public administrative, education and health services. The post recovery experience shows that private sector knowledge intensive services have once again been a strong provider of new jobs. Between March 2010 and March 2011 private knowledge based services created over 100,000 jobs compared with 65,000 in other market services, while production and public services contracted.[4]

4 Workforce jobs definition, Office for National Statistics

Looking further ahead, we know public based services will contract over the next few years and it is likely long term growth will be modest and focused in areas such as provision of education and healthcare where demand will continue to rise. High and medium tech manufacturing will create few net new jobs itself, but will remain the key export industry for the UK and a big driver of innovation – both technological and non-technological – and a source of new jobs in knowledge intensive services. Financial services has not been a significant generator of net new jobs in recent decades and it is unlikely to become so in the face of labour saving technologies even if – as we advocate – the sector re-engineers to become more friendly to all forms of innovative enterprise. The financial services sectors future role in the innovations system is to provide equity capital and loan finance where and when it is needed and on an appropriate scale to support both large scale infrastructure investment and innovative SMEs.

This recovery will be even more reliant on private sector knowledge intensive jobs – whether generated by the expansion of the sector in its own right or from the growth and expansion of allied sectors such as high tech manufacturing – as one of the key employment drivers. We can also expect more traditional services such as retailing and hospitality to contribute significant numbers of jobs, but future growth will be less robust than in the past. Consumers will never get credit as easily or as cheaply as they did in the decade before the recession and much of the expansion in sales will come from less labour intensive on-line retailing. Healthcare will also grow in response to the demands of an ageing population.

The challenge in the UK is all the greater in a decade of public austerity. The public sector must deliver high quality public services with highly constrained resources. The public sector does not lack creative well-educated people and parts have proved highly innovative. But overall the institutional mechanisms that drive innovation must be strengthened – from remuneration to what drives successful public sector careers. Moreover, the public sector is a key enabler of innovation in the private sector, not least through public procurement. Weak innovation ecosystems in the pubic sector also weaken innovation potential in the private sector.

Much attention has rightly been given to job generation by high growth SMEs, not least by The Work Foundation.[5] This has to be a key focus because looking at the past pattern of employment growth, almost all the net growth in employment among SMEs has come from those based in knowledge intensive sectors: so too will a disproportionate share of total jobs in the future. SMEs are a major source of new technological and non-technological innovation, challenging incumbents and speeding up the spread

5 Lee, Levy and Peate (2011) Ready Steady Go. London, The Work Foundation

of new practices. Their place in the innovation ecosystem is complex. Many are part of networks and have a symbiotic relationship with larger companies. Some are comfortable operating on the international stage, and some remain firmly focused on regional markets. The evidence also tells us that high growth firms are scarce (most estimates suggest less than 10 per cent of all firms) and many have been established for many years. Start-ups remain important in sustaining market dynamics, but cannot be the sole focus of enterprise policy.

Chapter 2 Riding the next innovation wave

We are in the middle of the digital revolution transforming the way in which our goods and services are produced, delivered and consumed. Innovations in renewable technology will revolutionise the energy sphere with the growth of the low carbon economy. Life sciences are changing our health care sector. New discoveries are becoming accessible at lower costs and are widely available throughout the developed world, but we need a fully functioning innovation ecosystem to unleash the economy's full capability to generate creativity, enterprise and growth.

Periods of economic crises have historically *not* triggered innovation. Bandwagons of innovations and associated economic growth cycles are generally triggered by boom periods.[6] Of course, particular companies industries and areas of the economy will be innovation leaders and 'hotspots' come what may, but typically innovation in these areas is often industry or product specific. It is the economy wide 'general purpose technologies' that are the single most important aspect of productivity and job enhancing innovation. An innovation-led recovery requires active long term intervention focused on developing an innovation system able to rapidly exploit the current and next waves of general purpose technologies.

General purpose technologies are technologies that over time become pervasive and widely applied across all sectors and all types of business. They are transformative, allowing new markets, industries, and business models to emerge potentially increasing organisational efficiency. They are also disruptive – killing off old business models and accelerating industrial decline. What constitutes a general purpose technology is often debated, even with historical insight. General purpose technologies are not just describing the 'kit' (the steam engine, the printing press, the computer) but can also be a process or even an organisational innovation with a technological root. The factory system, lean production, and internet based trading systems can all be regarded as general purpose technologies.

The hopes that a new technology revolution would provide much faster sustainable growth voiced by some commentators in the late 1990s have proved unfounded. This in part comes from a misunderstanding of GPTs. In any technologically advanced market economy new technologies, markets and business models constantly replace the old technologies. GPTs are among the most important in driving this process forward because of their widespread application. They provide the basis on which future growth is based rather than necessarily increasing the sustainable growth rate. We must replace the old sources of pre-recession growth with innovation led growth.

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6 Freeman and Perez (1988): 'Structural Crises of Adjustment: Business Cycles and Investment Behaviour'. In Dos, Freeman, Nelson, Silverberg and Soete (ed). Technical Change and Economic Theory. London: Pinter Publishers. 38-66

The potential losses from slow adoption are rising as other countries get better at translating innovations into competitive advantages and the speed of introduction and development of successive innovation waves speeds up. Distance and time provide little defence in the 21st century. Moreover, even firms and organisations who quickly realise the potential of new technology driven processes and business models and prove themselves to be quick and effective adopters will struggle if the external environment is unfavourable or non responsive. The speed and quality of the national broadband network, the responsiveness of the education and skills system, the ability to draw on scientific and non-scientific knowledge in universities, management schools, and other knowledge hubs, the ability to access capital – all of these will influence the ability of an economy and the firms within it to absorb GPTs.

The pace of technological and market change is accelerating. One reason for the speeding up is that innovation stands on the shoulders of the stock of scientific and technological knowledge and that stock is expanding very rapidly across the globe – so rapidly that simply keeping pace with what is genuinely new in the world is a major challenge. Inventions in particular areas can happen very quickly after an initial breakthrough – including rediscoveries of processes that could not be furthered at the time because they depended on other discoveries. Moreover, new ideas and techniques can spread very rapidly with modern communications and open trading systems. And global capacity to develop and exploit new ideas is rapidly expanding, with new capacity in emerging economies adding to that in the established centres of the OECD.

We can identify at least six innovation waves since the start of the Industrial Revolution. The waves arise from the bunching of basic innovations related to new general purpose technologies and which in turn launch technological revolutions. Originally, the waves were estimated to last about 50 to 60 years. Over time, the waves have become shorter over time illustrating an increasing intensity of industrial revolutions with more transformative powers. The first waves in the 19th century typically lasted up to 60 years, the more recent 30 years, and the next waves through to 2020 and beyond only 20 years or less. **Table 1** gives a summary.

Table 1: Business cycles of industry innovations and revolutions of 'general purpose technologies'

LONG WAVES	GPT	Growth carrier	Industrial innovation period	Cycle length (years)
WAVE 1	Water power	Textiles/cotton	1785-1845	60
WAVE 2	Steam power Steel	Railway Heavy engineering	1845-1900	55
WAVE 3	Electrical engineering Chemistry	Electrification Synthetic industry Agricultural chemicals Photography	1900-1950	50
WAVE 4	Petrochemicals Oil	Automobiles Aviation	1950-1990	40
WAVE 5	The digital economy Software The Internet Broadband Micro electronics Computers	New media Knowledge intensive services Manu-services	1990-2020	30
WAVE 6	Health economics Life sciences Low-carbon economy	Pharma sector Health services Fusion, Solar energy Nano-technology Robotics, Artificial Intelligence	2020-2040	20

Source: Freeman and Perez (1988) and The Economist (February 1999), Big Innovation Centre – The Work Foundation (2011).

In the current innovation wave, the digital economy is a major focus. Clearly computers, micro-electronics, broad band services, the internet and software are key factor inputs which are available at falling prices, rapidly increasing in supply (both in quantity and quality/computing power and broad band speed) and they have pervasive applications, in terms of a clear potential for their use throughout the economic system. Our foresight of the 21st century prospects of grand challenges and business opportunities are expected to be in the areas of life sciences and the low carbon economy.

For a new innovation and investment system to take off, the previous paradigm has to be replaced by a new paradigm offering solutions. Wave 4 in the table above caused a cheapening of mass consumption products allowing a consumer revolution and removed limitations for scale production through assembly-line techniques and standardisation of components and materials. The current wave 5 of the digital economy, microelectronics and computing overcame the inflexibility of the dedicated 'economies

of scale' assembly line partly by 'economies of scope' and flexible manufacturing systems, made possible through electronic control systems (e.g. CAD – computer aided design). Flexible production systems also make it possible for client based (or small batch) production, as well as production to order. The direct coordination of demand and supply allowed less unproductive stock to be carried.

The new patterns of industrial location and urban development through the dual uses of the automobile and air transport in wave 4 allowed the transport of raw material and workers so that distance became less of an issue. The current wave 5 removed the distance problem via the Internet in which shops, work places and markets and trade have global reach through interactive web services. The physical and operational boundary of the firm has also dissolved from more fixed value chains into value networks and dynamic market configurations made possible through the Internet. This has resulted in the outsourcing of many knowledge intensive services, causing productivity growth in a new specialized knowledge based sector.

Anticipating exactly which technologies will turn into genuine GPTs in the future based on current technological developments is difficult. For example, nano-technology is many years away from any industrial application, while robots are confined largely to manufacturing production lines despite wildly optimistic prediction of at least semi-intelligent machines. Other areas such as technologies associated with the life sciences are coming on stream but it is not yet clear how widely applicable they will be. The Technology Strategy Board (TSB) has published a series of comprehensive assessments based on the current state of play in a number of areas that indicate the potential and how the UK currently stands in each area.

The innovation system will help the 2020 economy rise to a series of major engineering challenges from the practical application of nano-technology and fusion power, carbon sequestration, health informatics and customised medicines, to cyberspace security and enhanced virtual reality to personalised learning.[7] Some organisations refer to 'enabling technologies' that cut across conventional research boundaries through combined innovations in, say, optical, chemical and biological applications in areas such as health care.[8] In the UK, the Technology Strategy Board (TSB) and other public bodies are pioneering centres of excellence – Innovation and Knowledge Centres – in universities to help business develop and exploit emerging technologies.

7 US National Academy of Engineering (2008) Grand Challenges for Engineering
8 Scottish Technology Group (2009) Towards a Brighter Future, Scottish Enterprise

Many of these will still be challenges in 2025 – even with a speeding up of the invention and innovation process there are still big lags between breakthrough and economy wide applications.[9] And some may still be beyond our technological abilities until well into the second half of the century. These long lead times make it all the more important to lay down the basic foundations now so that we are well placed to take advantage of whatever emerges as the next break-through in general purpose technology.

9 The TSB estimates 3 to 7 years from concept to early stage commercialisation and 7 to 15 years for market impact (Emerging technologies and Industry, Interim Assessment)

Chapter 3 Towards the next stage of innovation policy – the ecosystem approach

History has witnessed different regimes of science, technology and innovation policy. We have moved from science focused policies in the 1950s and 1960s, through technology policies in the 1970s and 1980s to broader innovation policies in the 1990s and 2000s.[10]

The traditional view of 'science policy' has placed the market (and market failure) as centre stage, where *indivisibility* and *appropriability* of returns to research and development (R&D) are key. The indivisibility problem occurs because R&D has very high fixed costs that cannot be broken down. The appropriability problem arises because output from R&D is highly uncertain (high risk) compared to, say, manufacturing products with proven technologies and also investors need sufficient protection to be confident that the knowledge produced from R&D cannot simply be appropriated by others. Traditional science policy has focused on creating incentives to invest in R&D, invention, and innovation via tax breaks and direct public R&D funding to overcome the problem of indivisibility and uncertainty, and via strong Intellectual Property Rights (patents and copyrights) to overcome the appropriability problem.

Whereas 'science push policies' are based upon market failures for knowledge, 'technology policy' is about stimulating the flow of knowledge from the science base into industrial application. Technology policy accepted the reality of interaction processes between science push and demand pull, i.e. the non-linear model[11], in which:

- No technology will be commercially successful if it is not needed or for which there is no demand (i.e. the market set limits and shapes the direction of inventive activity), and
- We cannot develop what we do not have the knowledge for, even if the need or demand is very large (i.e. science sets limits and shapes the direction of inventive activity).

Thus, science policy is not enough. Invention and innovative activity are also driven by changes in expected demand, the competitive structure of markets, and the ability of firms to realise economic benefits from their R&D. Successful market economies are not just driven by innovation in technology, but in all aspects of production, distribution, consumption and support institutions. Innovation is much more than the step between the invention and dissemination of new products and services. In order to absorb all the economic and societal benefits from our new technologies we need to see matching innovations in organisational structures, business models, financial systems, skill

10 Lundvall and Borras (2005): 'Science, Technology and Innovation Policy', in Fagerberg, Mowery, and Nelson (eds.): The Oxford Handbook of Innovation. Oxford and New York: Oxford University Press, 599-631

11 OECD (1992): Technology and the Economy. Key Relationships. Paris: OECD. Dosi (1982): Technological paradigms and technological trajectories, Research Policy 11, 147-162

structures and education systems, regulation and property laws such as IPRs, and more. Thus, innovation cannot be thought of as a simple linear progression from a new idea to market. All innovations depend on the combination of three factors:

- New knowledge – this can be something totally novel (i.e. radical), or the continuous development and combination and application of something tried and tested elsewhere to a new situation (i.e. cumulative and incremental);
- Resources – all innovations depend on the mobilisation of some form of targeted resources (financial, time, effort etc.) to support and advance the innovation process; and
- A market connection – whether it be a private market or some form of the public sector (large buyer) or a selection by a benevolent government always play a role. A key test for an innovation is its ability to create benefits by delivering something that is actually demanded.

All of these three interconnected and interactive factors need to be stimulated to drive innovation This highlights the importance of an existence of dynamic networks and systems of public and private organisations, including intermediary institutions.

Innovation policy therefore needs to focus on promoting economy wide diffusion of the current and next waves of GPTs through the development of frameworks and systems – an innovation ecosystem approach. But even if the technologies are common, the enablers and the barriers to diffusion will differ from sector to sector. Industrial strategy needs to identify the key enablers and remove the barriers to let the UK exploit comparative advantage in areas such as the digital economy, the creative economy, the low carbon economy, manu-services, and health and life sciences. The next stage in the evolution of innovation policy is to develop a systems based approach.

Government policy has been active in some areas. For example, the science budget has been protected from cuts in cash terms and the support of private sector investment in R&D increased significantly through more generous R&D tax credits. The government has also strengthened innovation and technology transfer institutions by, for example, establishing a series of centres under the guidance of the Technology Strategy Board.

Another area of recent government activity is the intellectual property regime. In a highly dynamic global economy, innovation and business models are radically reforming all the time, and the regulatory regime must keep up with them. Future IP policies must focus on whether they create and expand the markets for ideas and creative expressions, regardless of the distribution of rights, or whether users are charged for accessing content. This is crucial because it is through these markets that we recover

research and development costs, incentivise innovation and competition, spread knowledge, stimulate entrepreneurship, and build the sustainable development of firms and industries. The intellectual property system must reward inventiveness and creativity throughout the economic system rather than the current somewhat winner-takes-all approach, and must close income and technology gaps within the industry.

The recent government-commissioned review on intellectual property and growth, known as the Hargreaves Review, was helpful in establishing a framework to encourage greater innovation. Although no concrete legislation has been put forward yet, there are expectations that the Coalition will adopt the Hargreaves Review's global and up-to-date perspective on the issues. These changes are urgently needed to bring the UK's IP regime in line with communication infrastructure in the modern world, as well as in line with consumers' and IP users' reasonable expectations. Should the government fully implement all ten of Hargreaves' recommendations then this would be clear evidence the government accepts IP as part of a broader innovation ecosystem. Piecemeal adoption of the recommendations risks losing sight of the bigger ecosystem picture: the long-term aspirations of our technologies, industries, and consumers.

While the Hargreaves Review is clearly a step in the right direction, it is not a panacea: policy makers, industry and researchers will still have to reconceptualise the role of finance in the value creating and innovating industries. We must re-think how we can incentivise the generators and catalysts in the creative spheres – and without recourse to damaging legal battles. To strengthen the UK's innovative sectors, places and markets via the IP system it is vital to think big about the role of emerging technologies, business models, and open innovation, particularly through reconstituted and more creative interactions between users and producers of IP. A truly dynamic innovation and investment system should acknowledge certain limitations of rights to owners, and begin to acknowledge some rights for IP users and final consumers – who now so clearly participate in the digital value-creation process.

As some academics have noted, this shift to user involvement in the value creation process make it appear highly unlikely that a strong – or, to put it another way, less flexible – IP regime is going to be fit for the knowledge economy and the digital age. Indeed, less flexible IP regime may even hold back innovation and entrepreneurship, and in some cases perhaps risks offering protectionism for firms that are actually less innovative. We need to revisit those frameworks deployed within international regimes and courts of all jurisdictions in the light of Hargreaves' recommendations.

However, in other areas the supporting infrastructure has been weakened. For example, the abolition of the RDAs will remove a significant amount of resources dedicated to supporting innovation. The Regional Growth Fund has no specific innovation objective, and it remains to be seen how far these changes lead to a net reduction in innovation support.

Within such tightly constrained departmental budgets, there is clearly little room for manoeuvre. However, overall the government has put much more emphasis on traditional economic policies such as lower corporate tax rates compared with support for science, technology, and enterprise and innovation.[12] In many other OECD economies there appears to be a much stronger emphasis on additional support in these areas linked to exploiting the next wave of general purpose technologies. There will be more scope in the future to reallocate public resources to support business investment in innovation focusing on those areas it would be unreasonable to expect the private sector to take a lead on and also investing more in innovation supporting initiatives within the public sector.

However, it would be a big mistake to see innovation ecosystem development in terms of just what the government spends directly on innovation support, which is always likely to be modest as a share of GDP – investment in other priority areas such as the digital and physical infrastructure and in support of the education system are equally important. Moreover, the power of an innovation ecosystems approach is that it allows the setting of frameworks and the establishment of the right relationships and knowledge flows between a number of key institutions in ways that potentially have far greater leverage and influence over the innovative potential of the economy.

An efficient innovation and investment ecosystem depends on intermediaries that operate in the mezzanine, between economic actors. They can be financial intermediaries, innovation specialists, research universities, creative institutions, specialist knowledge service providers, supply chains and SME networks, anchor institutions, and others. A fully functioning innovation and investment ecosystem depends on all of its actors and institutions, and their linkages and interactions.

Because of the complex architecture of this construction of parts and connections, we need to set out a clear rationale of a system approach for public and private action. The rationale for policy action is to address failures in the innovation and

12 Innovation and enterprise supportive policies included higher R&D tax credits for SMEs, enterprise allowance scheme, entrepreneurs tax relief, increased science spending. Table 2.1 Budget Policy Decisions, 2011 Budget Statement

investment ecosystem. The diagnosis for policy action is about uncovering the actors and institutions that lead to successful innovation, and to identify where policy support should go. Weakness can arise in two areas:

- Missing actors: demand (consumers), companies, knowledge institutions, third parties (banks etc), government (policymakers);
- Poor institutions: Infrastructural failure, institutional failure, interaction failure, capability failure.

When considering innovation system policy intervention we need to consider the system parts (i.e. the players) and the linkages (i.e. the institutions defining the rules of the game):

- The players: Innovation is an interactive process in which innovative firms and individuals interact with other players (research institutions, customers/demand, authorities, financial institutions/banks, other firms etc). The innovation process is shaped by reciprocity and feedback mechanisms;[13]
- The institutions (setting the rules of the game): formal and informal institutions (e.g. IPR regulation, tax regulation, culture etc) shape the interaction between the actors. It is these support institutions and links and relationships between the players that determine how well the innovation system operates.[14]

In **Table 2 and Table 3** we set out one way in which an innovation systems approach could be developed, based on existing conceptual classifications.[15]

13 Lundvall, Bengt-Åke (ed.) (1992): National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning, London: Pinter Publishers. Richard Nelson (1993) National Innovation Systems: A Comparative Analysis. New York: Oxford University Press. Edquist, C. and McKelvey, M. (eds.) (1997) Systems of Innovation; Growth, Competitiveness and Employment, Cheltenham: Edward Elgar

14 North, D. (1998). 'Economic performance through time' in Brinton, M. C. and Nee, V. The New Institutionalism in Sociology. New York: Russel Sage Foundation, 247-57. (this is Douglas North's Nobel-Price Lecture)

15 Interpretation and further development of the conceptual classification in Woolthuis, Lankhuizen and Gilsing (2005)

Table 2: Innovation system failures

Rules/system failures		Players/actors				
Institutions which shape interaction between actors (i.e. rules of the game)		Demand: Final consumers Business consumers Public procurement (large buyers)	Companies: Start-ups SMEs Large firms Multinational corporations Regional focus Sectoral focus Global focus	Knowledge institutions: Universities Public research organisations (PROs) Private research organisations Technology institutions	Third parties: Banks Intermediaries Sector organisations Employment organisations, unions Consumer organisations, watch-dogs	Government: National (UK, including: England, Scotland and Wales) Regional councils International (EU, OECD, UN, WIPO)
	Infrastructure failure:	**Physical infrastructure:** (ICT & telecom, energy networks, transport, accommodation, etc). S&T infrastructure (skills for innovation, teaching facilities).				
	Institutional failure:	**Formal institutions:** (IPR law, employment law, technical standards, health and safety regulation). Informal institutions: (culture, entrepreneurial spirit, trust, risk-adverse, willingness to share).				
	Interaction failure:	**Platforms and networks for coordination, knowledge sharing and interactive learning:** Universities' Technology Transfer Offices, Technology Strategy Board, Design Council, NESTA, Big Innovation Centre, etc.				
	Capability failure:	**Capabilities for flexibility & transition failure:** (learning potential, ability to adopt to new technologies, limited in their technological horizons). Government failure: (i) When government intervention causes a more inefficiencies, (ii) The government's failure to intervene in a market failure situation. (iii) Government failure in recognizing the systemic character of innovation and to intervene during system failure. User capability failure: (incompetent users holding back market growth).				
	Traditional market failure	**Incentives problems to invest in R&D:** (indivisibilities, high risk, long time horizons – inadequate returns for private investors).				

Table 3: Diagnosis of (poor) institutions setting the rules of the game

Institutional focus points	Diagnosis of institutions which shape interaction between actors
Infrastructural failure	Physical infrastructure (banks, ICT & telecom, energy networks, transport, accommodation, etc); S&T infrastructure (availability of knowledge, skills for innovation, teaching facilities).
Institutional failure	Hard formal institutions: General legal system (IPR law, employment law, corporate governance) and specific regulation (technical standards, health and safety regulation etc); Soft informal institutions: Culture and social norms and values (entrepreneurial spirit, trust, risk-adverse, willingness to share resources).
Interaction failure	Poor user-producer interaction, in general; Platforms and networks for knowledge sharing and interactive learning: Bridge institutions such as Universities' Technology Transfer Offices, Technology Strategy Board, Design Council, NESTA, Big Innovation Centre, etc. Too internal orientation of some firms (tunnel view) and poor user-producer interaction; Too dominant players (examples from the media and entertainment sector); Financial institutions' interaction with SMEs as well as large firms.
Capability failure	Corporate capabilities: Firm, especially small firms, may lack the capabilities (such as flexibility, learning potential, and resources) to adapt to new technologies and market demand. Transition failure: firm are necessarily limited in their technological horizons, which are challenges during major shifts in technological regimes. Policy capabilities: Traditional government failure: (i) when a government intervention causes a more inefficient allocation of resources than would occur without that intervention, and (ii) likewise, the government's failure to intervene in a market failure. (iii) government failure in the context of systems as a failure to recognise the systemic character of innovation and to intervene during system failure in order to facilitate growth and prosperity. User capabilities: incompetent users holding back market growth. Lock-in: Firms, inter-firm networks, industries, socio-economic systems, policies and locked into a particular technological paradigm (complex of scientific knowledge, engineering practices, process technologies, infrastructure, product characteristics, skills and procedures).
Traditional market failure	Serious incentives problems to invest in R&D (large scale, indivisibilities, long time horizons – inadequate returns for private investors).

We will be developing these frameworks as part of our work to map, explore, and develop the first comprehensive account of the UK's innovation and investment system – and what can be done to fill in the missing pieces and complete the connections between the different components. In the next chapter we set out the main research related agenda of the Big Innovation Centre over the next three years.

Chapter 4 The Big Innovation Centre – working towards big solutions

The Big Innovation Centre will bring together a unique array of companies, trusts, universities and public agencies. There is agreement that this vision of an ecosystem with interlinked institutions and processes must be at the heart of the Big Innovation Centre. To set out what the different parts of this ecosystem should look like, the Centre will pursue five key work programmes, all united under the over-arching vision, to make a UK Global Innovation Hub. This ambition is critical in order to create jobs and foster growth, prosperity and welfare at every level of society. The five key work programmes are:

- **Building the UK's innovative markets, places and networks –** This work programme will identify the emerging technologies and sectors that will see rapid innovation over the coming decades. What are the new business models in which sectors and how can they achieve scale fast? How crucial is open innovation? And what can be done to ensure that all parts of the country have innovative capacity?
- **Building an innovation friendly financial system –** This work programme will reconceptualise the role of finance in the innovation and investment system in general and banks in particular;
- **Universities as interactive partners in systems of innovation –** This work programme will study the role of universities and public research organisations (PROs) as key nodes in the innovation network, as generators of knowledge and as catalysts of business spin-off institutions;
- **Skills for innovation –** Here the focus is on identifying which higher and technical skills are pivotal for innovation and productivity – and how the university and college system can best deliver them;
- **The enterprising state –** Regulation and public procurement are two key instruments to drive innovation, and this work programme will look at how the public sector can design markets which best support innovation and investment.

We will bring together each of these work programmes by reality testing evolving ideas from leading innovative companies. We will ensure a high practical content by developing innovation networks and petri-dish sites for experimentation and innovation by sponsors and their networks. And we will work hard to ensure the emergent framework is SME friendly: Britain lacks the institutional framework to support its 'Mittelstand', and one of the aims of the Centre is to address this shortcoming.

Building the UKs innovative markets, places, and networks: is the UK ready?

Innovation does not take place in a vacuum. It is a complicated process that involves many different players, including businesses, customers and a range of intermediary institutions. The rules and frameworks within which these interactions take place play a decisive role in driving innovation. Getting this innovation system right is essential to unlocking the UK's innovative potential and shifting the economy onto a more sustainable footing. But building an effective innovation system is not straightforward; it works at many different levels, from nationwide down to individual places and markets. Different parts of the economy have different needs, and a systems approach to innovation policy must reflect these differences.

The challenges

Today's economy is so complex that innovation is rarely driven by a single firm working in isolation. Even brilliant entrepreneurs do not develop groundbreaking innovations on their own; they rely on a wide range of partners to turn ideas into innovations, from initial financial backing to support in developing and marketing products. Almost all firms rely on a network of other businesses and institutions to help them succeed, however big or small. These interactions are not confined to particular sectors of the economy, or limited by geography; they cross such traditional boundaries in unpredictable ways. This means that the firm and the sector are rarely the best levels at which to consider innovation; instead, it is these complex networks that drive innovation.

The rise of the innovation network has been recognised by many firms, who have shifted towards an 'open' approach to innovation. This means ceasing to see innovation as something that can only come from within an individual firm, and looking to other firms and institutions for breakthrough ideas. In making this shift to an open model, firms need to become better at recognising how they interact with their wider networks, and identify how they can position themselves to make money within these networks.

The role played by innovation networks also has implications for how we account for growth in the economy as a whole. Innovation and economic growth are concentrated in certain parts of the economy; however, these fast-growing parts of the economy have a similar proportion of fast-growing firms to declining parts of the economy. This suggests that fast-growing parts of the economy are not driven by individual firms, but by broader networks that support innovation and generate new economic activity. The better these networks function, the faster they should grow; and the state has a major role to play in this. The growing importance of networks requires a shift in innovation

policy. The state must move away from a static approach that focuses on the barriers faced by individual firms and specific market failures, and look more systematically at the networks that support innovation.

Within these networks, markets play a key role in driving innovation. They are one of the key links between the different players in the innovation ecosystem, and they connect businesses with their customers. Well-designed markets should allocate resources efficiently between different economic activities, and should promote competition. But most importantly, they should continuously expand and grow; economic growth ultimately means more transactions taking place between buyers and sellers. This means growing existing markets, by making a wider range of exchanges possible, and creating new markets with new technologies and new products.

Markets are affected by a wide range of factors. Technological advances – from the railway to the internet – can transform markets, creating new platforms for exchanging goods and information. Laws governing property rights, competition and regulation define much of the shape of a market; they determine who owns what, and how things can be bought and sold. It is vital that markets inspire confidence among participants, so that businesses and customers can invest and take long-term decisions. At the same time, the government creates and plays a major role in many markets, through its role as a funder, a buyer and a provider of services. All of these factors must be considered in designing innovation-friendly markets.

Another key factor behind innovation – and one that is often overlooked – is the role of place. Despite predictions that the knowledge economy would make geography irrelevant in the economy, it has become more important than ever. Towns and cities play a significant role in fostering innovation, primarily because of the range of people they bring together. As a result, the gap between the most and least successful economies in the UK continues to grow, which has led to a two nation recovery in the economy.

The UK's innovation system is highly centred on existing centres of excellence, especially in the greater south east where the global hubs of the knowledge economy tend to gravitate. Without a stronger innovation system in the rest of the UK, the national capacity of the system to expand and respond will be hampered. Moreover, UK based firms with find themselves facing higher costs and increased competition for scarce resources if they are forced to confine their investment to the same geographical areas of the economy.

Building an innovation friendly financial system

The British financial system is highly concentrated, very transactional and highly internationalised. There is a bias to servicing the needs of large multi-nationals, private equity groups and hedge funds together with an accent on residential and commercial property lending. While this has some advantages, in particular in meeting the financing needs of large trans-nationals, it has produced both a tendency for systemic instability and persistently to underfund small and medium sized enterprises (SMEs), in particular fast growing high value added SMEs from which the lion's share of innovation and jobs growth is likely to come.

Any programme for rebalancing and rebooting the economy along with strengthening the investment and innovation ecosystem will require a transformation in this approach. The importance of knowledge intensive SMEs with fast changing business models in an open innovation ecology as growth drivers raise major questions about the degree to which current financial structures support innovative growth. There is already a substantive financial reform agenda on the table: Project Merlin, the Independent Banking Commission, the consultations initiated by the Department of Business, Innovation and Science over financial short-termism and the costs of excessive takeovers and the proposals to create a Green and Big Society Bank.

The challenges

The first critical challenge is to build an innovation friendly financial system. With the British banking system under enormous criticism for neglecting its core business – lending to support business generation and growth – there is an urgent need to establish hard evidence to explore whether this criticism is justified and to the extent it is, to propose new ways in which British banks – either in their current or reformed structure – support innovative enterprise. The Big Innovation Centre proposes to identify and evaluate the evidence about UK bank lending practices, to explain why this has happened in relation to current thinking about risk appetites and to propose potential reforms and new approaches.

Although it is a common criticism that banks do not support high growth, high innovation SMEs, there is a paucity of systematic evidence that gets beyond anecdote. While there are figures on macro-trends in lending, details, for example, of loan to value ratios for collateralised lending to SMEs, or the cost and term structure of lending are hard to find. Even the Rowlands Review on business lending for the last government had little new information, relying on a combination of macro figures, opinion surveys and qualitative evidence. One of the aims of our research will be to close this gap.

Banks approach to SME lending is determined by their attitude to risk. The business model associated with residential mortgage lending and acting as intermediaries for large companies is well developed: this allows for lending at scale in ways that are readily realisable for cash on well-understood matrices of risk. Residential and commercial real estate default rates are well understood, easily accommodated by mathematical risk assessment models and the lending can be securitised to be realisable for cash. The cost structure in the branch network associated with mortgage lending is also well understood. Similar criteria exist for lending or syndicating loans to large corporate customers.

Lending to SMEs is completely different. The risk is much less easily turned into mathematical models (apart from those related to the economic cycle). The costs associated with lending are much higher. The loans are much less easily securitised. The risks are very particular to each enterprise and much harder to bundle into securitisable assets. The Bank of England does not buy commercial paper at its discount window. Thus, there is an enormous need to offset these risks by identifying property collateral, but this benefits incumbent firms rather than fast growing SMEs.

Other countries have solved the risk conundrum in a number of ways. Germany has its industrial banks and in Sweden the Handelsbanken has flourished. In Japan and South Korea, banks historically take equity stakes in enterprises, have cross shareholdings and organise banking to families of companies – the industrial house bank model. In the US state banks have been conferred protected markets by prohibitions on interstate banking. In all these countries the Central Bank buys commercial paper as part of its open market operations, so that business lending can be quickly realisable for cash. These are all means of mitigating and hedging risk that are unavailable in the UK. The research will survey the international evidence on the organisational forms in which banking takes place to ask the question how similar models could be reproduced in a British environment. There are likely to be substantial implications for the way the Bank of England banks to the banks in its open market operations and the approach the FSA takes in establishing and regulating varying risk weightings for categories of assets.

The Discouraged Economy[16] (published by The Work Foundation in July 2011) made an early submission to the Independent Banking Commission on the macro-structure of the financial system. A fuller report, to be published at the end of the year, will look at some of the changes that could speed up the flow of both bank credit and equity capital. This will include regional coverage, whether public capital is need to support private capital and how that might be done, how to revive Britain's depleted venture capital industry,

16 Hutton and Nightingale (2011) The Discouraged Economy. London, The Work Foundation

how to develop the Green Bank, and how the Business Growth Fund might be leveraged and turned into a larger and more effective version of 3iGroup Plc – and work alongside existing banks.

Universities as interactive partners in systems of innovation

Universities and public research organisations (PROs) are not simply suppliers of knowledge but interactive partners in our economy.[17] The UK's universities have on average performed well by international standards in generating innovative research and great strides have been made in improving the commercialisation of that research over the past 20 years. The UK higher education sector is a £59bn sector with significant and rising exports and all types of universities are innovation partners.[18] It is also important to recognise that one of the great strengths of the UK system is the autonomy of individual institutions and while government can help set the frameworks in which university-industry collaboration operate the risks and responsibility lies with universities and businesses themselves.

Academics and PROs produce a wide range of knowledge and intellectual property (IP) products, which can be transferred to industry, government and other external stakeholders in different ways. The models of knowledge transfer from the university 'supply-side perspective' involving technology transfer offices, scientists, external commercialisation companies and universities themselves has become a subject for inquiry in academic research and by government policy. Studies have mainly focused on STEM (science, technology, engineering and mathematics) disciplines.

There is much good practice within the university sector but there is no one model of best practice that fits all The characteristics of universities matter in the universities' use and effective management of their intellectual property – especially in areas such as knowledge transfer, creating awareness of academic research base, knowledge feed-back processes into the academic research base and realising financial benefits. The evidence suggests that UK universities, like their US counterparts, are continually experimenting with ways in which to diffuse knowledge. The system will develop by supporting and strengthening the ability of universities to learn and apply the new best practices that are evolving from the HE sector.[19]

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17 Andersen and Rossi (October 2010): The Flow of Knowledge from the Academic Research Base into the Economy: the Use and Effectiveness of Formal IPRs and 'Soft IP' in UK Universities. Published by the UK IP Office. Work commissioned by the Strategy Advisory Board for Intellectual Property Policy (SABIP)

18 Abreu, Grinevich Hughes, and Kitson (2010) Knowledge Exchange between Academics and Business, Public and Third Sectors, UK-IRC

19 The Higher Education Knowledge Exchange System, report to HEFCE by PACEC and the CBR, University of Cambridge

The challenges

The challenge is how to sustain and further develop our current position in a world where the quality of the university system is now seen as a priority by almost every OECD economy and major corporations have an unprecedented choice between competing centres of excellence.

We need to get a better grip on what has worked for our large renowned universities specialising in STEM subjects (e.g. in terms of spin-out and licensing agreements. This is an area especially important in growing our high tech manufacturing sector and we have already started work looking at how the university-industry linkages can be improved in the life sciences. Another critical area will be aerospace. We also need to study how universities themselves are building networks like Global Ventures Lab (GVL), led from Berkeley University in the US, or the N8 group of British Northern universities.

It is also essential that we remember to recognise the heterogeneity of UK universities, in terms of history, age, size, geographical location, regional ties, research intensity, research discipline, entrepreneurial culture, etc. Different types of university play different roles in the UK innovation and investment ecosystem, and therefore have different aspirations, and perhaps should be evaluated using different performance indicators. As 'one size' management of universities does not fit all UK universities, we need to research how flexible policies can embrace variety, as different universities solve different problems.

Research also needs to address the obstacles in the innovation and investment ecosystem which affect universities research and knowledge transfer performance, and eliminate the inefficiencies. Also, we have limited understanding of the role of the users or adopters of university knowledge, and of the differences across firms and sectors on the 'demand side' of the university-industry relationship. Knowledge flows are increasingly two way where engagement also benefits the university and working relationships are based around collaboration and partnership rather than the simply transactional. The strategic challenges and experiences of users when adopting knowledge flowing from the academic research base need to be researched to complement the existing research on the university supply-side. The innovative capacity of the economy needs to be raised to ensure that demand matches supply. One of the key problems identified in the Hauser report[20] was the crucial gap between research outputs and their successful commercialisation. An important focus of the Big

20 Hauser (2010) The Current and Future Role of TICs in the UK

Innovation Centre will be learning from practice in universities - and in businesses - and helping that inform policy on university-industry interaction. Academic research papers help us in the long-term but it lags practice.

Finally, as research has tended to concentrate on the STEM disciplines, we have limited understanding of the flow of non-STEM knowledge from the academic research base into use by industry; such as art, media, cultural studies, economics, management, psychology, law, classics, philosophy, politics, linguistics and communications. The latter is just as important given the huge investments firms are making in intangible assets. Moreover, of increasing value are people who can operate across the disciplines – we need creative technologists as well as creatives who understand the technology.

Skills for Innovation

Innovation depends on the capacities of individuals to create new knowledge and to apply it in the form of new products and services. This relies on the ability of individuals to create value by connecting fully with the innovation system. A strong skills base will therefore be critically important to developing a successful innovation-led economy. The UK has a mixed record here. The growth of the knowledge economy has been supported by a dramatic expansion in the provision of tertiary education. These high-level skills are likely to be critically important to the future of our innovation system. We can be confident that our future growth will be driven by knowledge intensive activities where graduate skills play a special role.

These reflect an ability to use tacit knowledge to assimilate, interpret and use a range of specialist information. They are therefore of special relevance for innovation in the knowledge economy. It is essential that our education and training systems produce the skilled people our economy will need in the future. However, concerns have been raised about the qualities of many graduates emerging from the current system.[21] For example, there has been concern that while the supply of scientists and engineers has gone up, their skills and qualifications may not be wellaligned with the needs of a modern economy.

The role of institutions in supporting skills at all levels is also of great relevance for innovation, and performance here is less encouraging. We also believe there is a direct and complex relationship between skills, innovation and productivity; more skills to drive innovation will also drive productivity enhancement. However, the UK Commission for Employment and Skills' report Ambition 2020 highlights a number of worrying challenges. They point to significant mismatches between jobs and skills – our complex

21 Levy (2010) Shaping up for Innovation. London: The Work Foundation

and unwieldy skills system struggles to align the supply of skills to the labour market. Of particular concern are apparent shortages of many high-level technical skills. An issue appears to be the low skills ambition of many UK employers.

The challenges

The first critical challenge is to develop a clear conception of what skills actually best support innovation, and how these skills develop in the context of the workplace contract. A recent review of the international literature concluded: *despite recognising the central role of higher level and broadly distributed workforce skills in promoting innovation, there has been little research within the field of innovation studies on this topic.*[22] There is a need to understand how the different risks and reward structures faced by entrepreneurs acting independently and 'intrapreneurs' operating within corporate environments impact on the skills needed to drive innovation.

There is clearly a special place within invention for high-level technical skills and the graduate disciplines of STEM subjects. These areas are often associated with the creation of new knowledge in advanced areas of research, and the practical aspects of these skills are of relevance for the process of scaling up new ways of thinking to create viable products and services. Confirming this, the RSA have highlighted the high percentage of graduate employees with a science or engineering degree in innovation active firms across manufacturing and knowledge intensive business services.[23]

These invention processes however, represent a limited view of innovation. The innovation system model is built on the fact that innovation depends not only on the creation and development of knowledge, but also on the application of new knowledge to create benefits (typically financial rewards). This highlights the importance of upstream processes which support the mobilisation of resources for investment in innovation and the downstream processes of new product selection, often performed within markets. Highly technical skills are not necessarily of particular relevance here.

From this perspective a broader range of skills are of relevance for driving and delivering innovation. For example, design skills, commercial skills or the ability to communicate highly complex concepts are often of special relevance. A key issue would be whether policy should encourage individual students to pursue a greater breath of

22 Toner (2011) Workforce Skills and Innovation (OECD WP 2011/1). Toner concludes: despite recognising the central role of higher level and broadly distributed workforce skills in promoting innovation, there has been little research within the field of innovation studies on this topic

23 RSA (2009) Hidden wealth: the contribution of science to service sector innovations

skills (drawing on the idea of a 'renaissance man') or encourage deeper specialisation and help to build a society which can better support interaction and co-operation between individuals with these skills in society (a renaissance society).

The second challenge is to show how higher and further educational and technical training institutions can best encourage the development of skills for innovation – both from and within corporations. For example, one area for investigation might be new ways of bringing together at Masters level different disciplines such as design and engineering or biotechnology and business. The open nature of local innovation systems presents a particular challenge here – skills shortages are consistently highlighted as a barrier to growth in lagging economies, however investments in human capital often leak out of target areas as high skill individuals tend to be highly mobile and cluster in the most productive and innovative places.

The Enterprising State: Public action to drive Innovation

Public action can come through direct support for innovation; building the right regulatory institutions and policy environment; and through using the purchasing power of public sector organisations. Regulation can take many forms – direct regulation such as setting standards; market based incentives (tax breaks); information; and promoting self-regulation and co-regulation. Some regulations help promote innovation but are set with the whole economy and broader objectives in mind – examples are competition policy and corporate governance. Others have a more explicit link to innovation such as intellectual property rights. Policy setting can have a strong effect – for example, driving innovation in green technologies and processes through the commitment to reduce carbon dioxide emissions.

Public procurement can help create new markets by offering scale for new products and processes that otherwise would be slow to come through and by demonstrating how innovative products and processes can produce efficiency and economic benefits encourage greater take-up by both businesses and consumers. It can also provide markets for new and smaller firms with new ideas about what to do and how to do them.

The challenges

A key challenge is how to make the regulatory system more innovation friendly. This would look at how to enhance the existing role of standards and measures to promote interconnectivity for example. Similarly, a robust competition policy is seen as promoting innovation, but current policy does not explicitly ask the question whether a merger or acquisition would enhance innovation. And there can be complex trade-offs

– for example, collaboration between patent holders may look anti-competitive but can enhance overall innovation.[24] How then do we ensure the development of collaboration between innovative firms does not become anti-competitive?

The second challenge is to reinforce the contribution of policy development to driving innovation. An obvious area where there has been some success is around the low carbon agenda, both in terms of green technologies, new processes, and new service activities such as carbon trading. Our work on the low carbon economy[25] suggests policy can do more to build the institutions that can create markets and reduce uncertainty for long term investors. In other areas,S the development of new ways of influencing rather than directing behaviour including increasing the public appetite for and confidence in new products and processes could be critical.

The third challenge is to increase the innovation impact of public procurement. Public procurement has struggled to reconcile often conflicting objectives – for example, sticking with the tried and tested or opening up markets for the new and cutting edge; delivering savings and greater efficiency now or in ten years time; going for scale which can mean cheaper and consciously encouraging middle to large firms most likely to make significant technological, or reserving a share of contracts for SMEs. The impact of such policies at local level is not well understood.[26] There have been repeated concerns about the ability of public sector public procurement officials and systems to cope with the demands placed upon it, not least around innovation – the development of open innovation systems in the public sector would help address some of these weaknesses.[27]

24 Box (2009) OECD Working paper, STI 2009/2
25 Levy (2010) A Low Carbon Economy. London: The Work Foundation
26 Uyarra (2010) Innovation opportunities through local public procurement, NESTA
27 Bunt et al (2009, 2010) The Human Factor and Mass Localism, NESTA

Chapter 5 Making the UK a global innovation hub by 2025 – the Enterprising State

The rise of the knowledge economy across all industrialised and emerging economies has been accelerated by globalisation. However, central to the vision of the Big Innovation Centre is the view that the competiveness and economic performance of firms, regions and nations still have to be understood from a more local context. This is not despite of, but because of:

- The globalisation of production, trade and labour mobility;
- The growth of trans-national corporations (TNCs); and
- Information and communication advancements and the emergence of the e-business.

These globalisation forces do not wipe out the role of local business networks, the nation state, but they reinforce their importance. Michael Porter set out in 1990, and the insight offered then is just as true today.

> *'Competitive advantage is created and sustained through a highly localised process. Differences in national economic structures, values, cultures, institutions and histories contribute profoundly to competitive success. The role of the home nation seems to be as strong or stronger than ever. ..... With fewer impediments to trade to shelter uncompetitive domestic firms and industries, the home nation takes on growing significance because it is the source of the skills and technology that underpin competitive advantage. Firms will ultimately succeed when they base their strategies upon improvement, innovation and a realistic understanding of their national environment. [..] The proper role for government is to push and challenge its industry to advance ... '*
>
> Porter 1990[28]

Not only SMEs are dependent on local environments, but TNCs also have limited mobility and are local dependent in the short run, as transferring specialising equipment and skills-needs and management to new locations will only be met with limited success unless it is accompanied by a matching ecosystem. At the same time, turning the UK into a global innovation and investment hub will not only make businesses located in the nation grow, but also attract foreign direction investment in the UK in the long run.

28 Porter, M. (1990) The Competitive Advantage of Nations. (Harvard Business School) New York: Free Press

Boards of directors, in practice, look at the innovation and investment ecosystem when they make investment decisions even if they have never heard of the concept. A key aim for UK policy makers should be to make the UK innovation and investment ecosystem so attractive that the UK becomes a key global innovation hub where talent is fostered, spurring economic growth, prosperity and welfare. A narrow innovation and growth policy will have at best marginal impacts on business decisions by both UK and foreign-based companies. Building a world-beating innovation ecosystem is not a one parliamentary-term project. Structural reforms operate over long time periods – there are some quick wins but typically many of the really big pay-offs will be over much longer timescales. It will take more than a decade to build the ecosystem parts, capabilities and institutions which are both attractive for local firms and which will attract foreign direct investment (FDI) to the UK. We have targeted 2025 as the year in which the UK will lead with a global innovation and investment hub fit for purpose.

The enterprising state needs to build a durable framework for long-term public action and incentives for private action to bring this about. We suggest a three stage approach:

- Analyse where system failures occur: What kind of failures and what is the role of the actors and institutions in causing these failures?
- Evaluate current policies: Do they address the right failures in the right way? Do they cause inefficiencies in the innovation system?
- Set out a framework plan for innovation and investment driven growth for the UK economy but be alert for the need for continuous adjustment, improvement and occasional abandonment of a proposal in the light of experience.

We have developed a preliminary public policy agenda for action for discussion and this is set out below – some of the proposals are specific and others will require more development. We recognise that in the next years, the scope for additional public resources to be committed in this area is limited. However, in setting future priorities and thinking of the next Spending Review period it is important that different priorities are established. For example, in the last Budget the ratio between expenditure on across the board corporate tax cuts and support for enterprise and innovation was roughly 4 to 1. In the next spending period we should work to reverse those proportions. In addition, some policy initiatives can be phased out if, as we fear, they prove unsuccessful. We have been critical of Enterprise Zones[29] and would advocate an immediate moratorium on new Zones and once the current tax concessions have expired

29 Sissons, A. (2011) Do Enterprise Zones work? London: The Work Foundation

after five years redirecting the resources towards innovation support. Other economies can easily imitate cuts in corporation tax. The sustainable comparative advantage is far more likely to come through making the UK innovation ecosystem world class.

The ecosystem approach – towards a public policy agenda

- Private and public organisations should think and act in terms of how they fit into the innovation ecosystem – requiring an ongoing mapping and evaluation of capabilities and shortcomings but also of successes and opportunities;
- Build the Technology Strategy Board (TSB) into the world's most effective funder of catalytic research into the development and application of general purpose technologies (GPTs) both to individual companies but also networks of companies;
- Aim to have the globally most sophisticated national network of Technology and Innovation Centres (TICs) organised as far as possible on open innovation principles and committed to supporting open innovation business models. As a first step bring forward the next wave of TICs, matching funding of £200m announced in Budget 2010;
- Co-develop with Britain's financial institutions a transformative structural shift in the supply of equity and loan finance to support innovative small and medium-sized enterprises (SMEs) in all regions and sectors;
- Bring forward the planned launch of the Green Investment Bank, and significantly increase its capital;
- Develop the Business Growth Fund into a modern version of the 3iGroup with capital of at least £10bn;
- Pledge to restore investment in the physical and digital infrastructure, focusing in particular on improving communications and facilitating the growth of innovative firms;
- Ensure access to high quality broadband service at low costs for all households and businesses, to increase the social and economic benefits from broadband use throughout the digital economy;
- Give the Regional Growth Fund an explicit innovation-supporting funding stream, matching previous spending of £400m undertaken by Regional Development Agencies (RDAs), and build a capability to do this in every English region along with the existing capability in Scotland and Wales;

- Develop new incentives and frameworks to stimulate the demand side from business for both technological and non-technological knowledge transfer from universities and other public research organisations;
- Require the TICs to establish knowledge transfer networks for open innovation business models;
- Revolutionise Britain's system of engineering and scientific training and apprenticeship, beginning with UKCES identifying what mix of high level and technical skills will best support the exploitation of the next innovation wave;
- Develop ownership structures that support shareholder responsibilities as trustees for long term growth. As a first step we should examine the feasibility of a specific requirement to consider the impact on innovation as part of the public interest aspect of take-overs and mergers;
- A key objective for public procurement, regulation and standards setting must be to enable and drive innovation across the economy and in key growth areas (such as the low carbon and digital economies and the life sciences);
- Build innovation impact into reviews of regulatory requirements and standards setting to help encourage the adoption of cutting edge technology, especially in the vital high tech manufacturing sector;
- Above all, understand that all these proposals reinforce each other. To think in ecosystem terms requires an embrace of the new openness, a celebration of scientific and technological possibility and a passion to make and produce. What will underpin the ecosystem approach is a reinvention of the spirit that animated the Industrial Revolution – the quest for useful knowledge for human betterment.

The economic and social prize for getting this right over the next fifteen years is immense. Growth had become over-reliant on a toxic mix of unsustainable asset price inflation, consumer debt, excessive risk in parts of the financial trading system, and a rising share of GDP devoted to public expenditure. This must be replaced by investment and innovation led growth based on the economy wide ability to successfully and quickly exploit the current and future waves of both technological and non-technological innovation. A credible growth and innovation strategy for the coming decades must have as its central objective making the UK one of the leading investment and innovation hubs in the world.

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