

Nesta...

PLAN I

THE CASE FOR INNOVATION-LED
GROWTH



About Nesta

Nesta is the UK's innovation foundation. We help people and organisations bring great ideas to life. We do this by providing investments and grants and mobilising research, networks and skills.

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EXECUTIVE SUMMARY

Since 2008, the UK's economic debate has largely been about short-term recovery. The argument has focused on which of two options will end the recession: Plan A or Plan B, austerity or stimulus. But neither addresses the UK's longer-term growth prospects. Growth depends on innovation — our ability to generate and adopt new knowledge and ideas. Decades of research have shown that innovation is the most important driver of long-term productivity and prosperity, and that innovative businesses create more jobs and grow faster. Yet despite the UK's many strengths as an innovative economy, there are crucial ways we are losing ground.

Plan I argues for a change of direction. It shows why fostering innovation must be a priority for the UK and for the government: why we need an environment where businesses have the confidence to invest, entrepreneurs are free to take risks, and barriers to new ideas and new entrants are low. It advocates an active role for government addressing issues like access to finance and education, investing where the private sector will not, and using its power as a purchaser, regulator and funder to support innovators. And it argues that we have much to learn from how the most innovative countries around the world — including the US and Finland, Israel and Korea — have combined active government support with highly entrepreneurial cultures.

The current state of innovation in the UK

The UK has many innovative firms and people, from world-beating creative businesses like Double Negative to its thriving business services sector; from advanced manufacturers like Rolls-Royce to world-class research universities; and from technology giants like ARM to the start-ups of Shoreditch. But behind their success lie worrying trends. Nesta's Innovation Index showed that investment in innovation by UK businesses has fallen sharply since the financial crisis of 2008: the most recent data suggests it declined by as much as £24 billion last year. This issue predates the credit crunch: in the period from 2000 to 2007, businesses' investment in innovation levelled off, investment in fixed assets fell and became increasingly dominated by bricks and mortar at the expense of technology, and companies accumulated cash. For many businesses, the 2000s were less an age of innovation than an age of cash and concrete.

Financing innovation

The last decade showed the disconnect between the UK's financial sector and investment in innovation and technology. Although capital markets exist to channel savings into new ventures, the capital raised by businesses on UK markets increased by 355 per cent between 1998 and 2007, while investment in innovation increased by only 54 per cent. Venture capital for early-stage businesses continues to be in short supply, while our highly concentrated and rapidly deleveraging banking sector makes growth finance hard to come by.

Public investment has fallen too. Despite some worthwhile initiatives, from the protection of public research budgets to the establishment of the Technology Strategy Board and Catapult centres, innovation is currently a very small part of what government does. In the

current spending review, discretionary spending on innovation accounts for £2.6 billion, a figure dwarfed by discretionary spending on other priorities such as aid (£8.5 billion) and health (£46 billion). Since the crisis, other governments, including the US, France, Germany and Korea have committed far more to research and other innovation spending than the UK.

Addressing this will require changes both to government spending priorities and to the UK's financial system. The financial crisis offers a chance to put in place, at scale, long-mooted plans to channel some of the £220 billion government procurement budget to innovative businesses. The upcoming 4G spectrum auction is expected to raise £3 to £4 billion, which should be committed to innovation. And some of the £40 billion infrastructure fund should be earmarked for the infrastructures of the twenty-first century, in particular smart electricity grids and super-fast broadband. These measures should be the first steps in a longer-term rebalancing of government spending from consumption to investment.

The UK must also put in place the financial architecture that businesses need to innovate and grow. Part of the 4G auction could fund a generous venture capital co-investment fund to help start-ups to grow. To provide larger-scale finance, the government should consider the establishment of one or more dedicated business banks, focused on innovative businesses, combined with an extension of credit easing.

The innovation system

We also need to improve the wider 'innovation system': the complex set of interactions between businesses, research institutions, consumers and government that helps turn ideas into reality. The UK has world-leading researchers, a good track record of generating university spin-outs, and internationally competitive clusters in a range of industries from financial services in London to video games in Dundee and from semiconductor design in Bath to biotech in Cambridge. But some universities are still overly concerned with spin-outs and IP licensing, not the wider benefits they can bring to businesses. In some parts of the country and especially in much of the UK's public services, innovation is scarce, either because would-be innovators have little support or because incentives to put new ideas into practice are weak. Our education system is ill-prepared to train people (whether children or adults) for the requirements of a changing economy, in particular because of its stark separation between practical and intellectual skills.

In some cases, the government can play a direct role in addressing these problems: by using voucher schemes to encourage collaboration between businesses and universities or between small and large firms, by working with industry to offer prizes for major technological challenges, or by encouraging the teaching of computer science in schools.

Bringing down barriers for innovators must also be a priority. In some cases, these are barriers to people, such as the migration rules that prevent skilled foreign students staying in the UK after graduating or make it hard for start-ups to attract the talent they need to thrive. In other cases, these are market barriers, such as overly restrictive planning rules that make it hard for businesses in clusters to expand or for their workers to find affordable homes.

Making the voices of innovators heard

Some of the proposals in Plan I are controversial. Making the proposals in Plan I a reality will require a more effective political coalition, from entrepreneurs to inventors and from social innovators to geeks. At present their voice is largely missing from economic debates. The issues they are concerned with were scarcely mentioned in the ruling Coalition agreement, or the previous government's economic programme. They are absent from the dialogue between government and financial institutions; and when business collectively takes a stand on issues, these have sometimes fallen off the agenda. This is in marked contrast to other countries where the innovation field is more visible, more supported and better understood. In the longer run, building a stronger coalition for innovation will be as important as the detailed policy recommendations, and vital if the UK is to shift resources from present wants and needs to future opportunities.

The full version of Plan I sets out 12 sets of policy proposals that we see as essential parts of the way forward. These — summarised below — could be implemented without any additional costs to taxpayers, or any increase in the deficit. The proposals would be funded by redirecting currently committed spending, and by using the windfall from the forthcoming 4G spectrum auction. In the longer-run, we hope that more ambitious options would be taken up.

Area of focus	The objective	Immediate action	Longer-term actions
Financial architecture	A financial system that supports innovation from its earliest stages through to international growth	Establish a £200m co-investment fund for early-stage ventures; give the Green Investment Bank freedom to borrow and develop new banks for Advanced Manufacturing and Life Sciences	A rebalancing of the financial system to reward innovation and long-term investment; more competition and diversity of sources of finance
The balance of government spending	Rebalance public spending from consumption to investment — education, science, technology	Invest the £2-4bn proceeds from the imminent 4G spectrum auction in science, technology and innovation	Making investment a priority in future government spending: a 0.5% shift would be equivalent to more than doubling the research budget
The government as a customer for innovation	A government that acts as an effective lead customer for innovation, buying new products from innovative businesses	Establish the Innovation Engine, drawing on the lessons of the US SBIR and DARPA, to channel £1bn of government procurement from innovative businesses	Channelling 1% of government procurement into innovative businesses, using the Innovation Engine and TSB
Infrastructure investment	The UK as a world leader in C21 st infrastructure: broadband and smart grids	Relax planning restrictions around innovation clusters	Channel half the £40bn infrastructure fund into superfast broadband and smart grids

Collective Intelligence	Making the UK the world expert on next-generation tools for orchestrating knowledge and collaborative creativity	Earmark a proportion of HE funds for radical innovations in knowledge creation; put design thinking at the heart of new Catapult centres	Make collective intelligence (collaboration, big data, open science) a defining research priority of the next decade
Incentives for invention	A system that inspires radical innovation, and rewards innovators, but does not privilege incumbents or patent trolls	Set up a £25m challenge prize fund to inspire the nation to tackle big technological challenges	Streamline the IP system, to reflect the realities of new digital technologies
Measurement, data and standards	Metrics that reflect how innovation really happens, and rigorous evaluation of whether innovation policies are working	Measure 'hidden innovation' in the economy, building on Nesta's Innovation Index	Reshape our innovation tax credit system to recognise hidden innovation as well as just R&D, introduce new standards for financial services data
Broad-based innovation	An innovative economy and society across the UK, not just in the south-east or in high-tech sectors	Back projects like East London's Open Institute or Manchester's Fab Lab to boost innovation where it is already thriving	Use big data to understand what innovation clusters really exist; give local public institutions a duty to encourage innovation
Innovation in the labour market	Using technology and social innovation to make the UK's labour market work better	Support innovative projects that link procurement to local jobs, training and apprenticeships, and encourage innovations around microjobs and microfranchises	Fund experiments in new schemes that use technology to match people and jobs; establish norm of one apprenticeship per £1m turnover; extend Studio Schools and other models to prepare young people for work
Public and social innovation	Making the UK the global hot-spot of social innovation and accelerate public service productivity gains	Fund incubators in key public service fields facing severest challenges (including social care); commit in spending review to a substantial fund, set aside from department budgets, to back evidence-based solutions to 'wicked issues'	Develop innovation skills across public services, and deep pools of practical experience on everything from incubation to scaling; grow a culture of evidence in public services (Red Book on evidence, 'What Works' centres)

Education	Creating the next generation of 'digital makers'	A C21 st version of the BBC's Computer Literacy Project	Giving all teenagers the chance to make, to design and to program
Removing barriers to entrepreneurship	Making it easier for new business to enter markets, and for innovative people to enter the country	Change the immigration cap to welcome skilled foreign graduates and entrepreneurs	Make the encouragement of new entrants a central goal of regulation; protect net neutrality

Nesta and partner organisations will be following up Plan I with more detailed proposals, as well as through our own actions as an investor in innovative firms, as a funder of programmes in fields such as digital education, and through initiatives such as the Centre for Challenge Prizes. A manifesto for the Creative Economy focusing on the creative industries will be published early in 2013. We welcome comments, ideas and improvements on both the diagnosis and the prescription of Plan I. The best innovations evolve and adapt. The same is true of the best innovation policies and we present this as a work in progress.

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The report also draws on past research done by Nesta and its partners, including the UK-IRC, SPRU, Imperial College, the Big Innovation Centre, the Manchester Institute of Innovation Research, Aston University, the OECD, the Campaign for Industry and Higher Education, Harvard Business School, The Massachusetts Institute of Technology, Sitra and Fundacion Chile, on Nesta's practical work as an investor in early-stage firms and social ventures and in encouraging social innovation.

All errors and omissions are of course our responsibility.

1: PLAN A, PLAN B OR PLAN I?

The 2008 financial crisis has turned into the longest downturn in modern times. One question dominates national and international debate: what can be done to get the economy growing again?

Two rival proposals aim to answer this question: Plan A and Plan B. Plan A stands for austerity. Its advocates, including the government, argue that the state must slash expenditure to reduce the deficit and avert a debt crisis.¹ Only then will investment flow and growth bounce back. Plan B involves stimulus. Its supporters argue that austerity is bad medicine, and self-defeating. Less demand leads to lower growth which leads to lower investment which in turn leads to lower growth. Instead, governments should increase spending to get the economy going again, whether through tax cuts, direct spending or finance for infrastructure. They should reduce the deficit when times are better.

This two-dimensional debate is hugely important. Yet it is also inadequate. Neither Plan A or Plan B offers a sufficient basis for a prosperous future, or an account of what the UK needs to do to thrive as a productive, dynamic economy.

The question of innovation

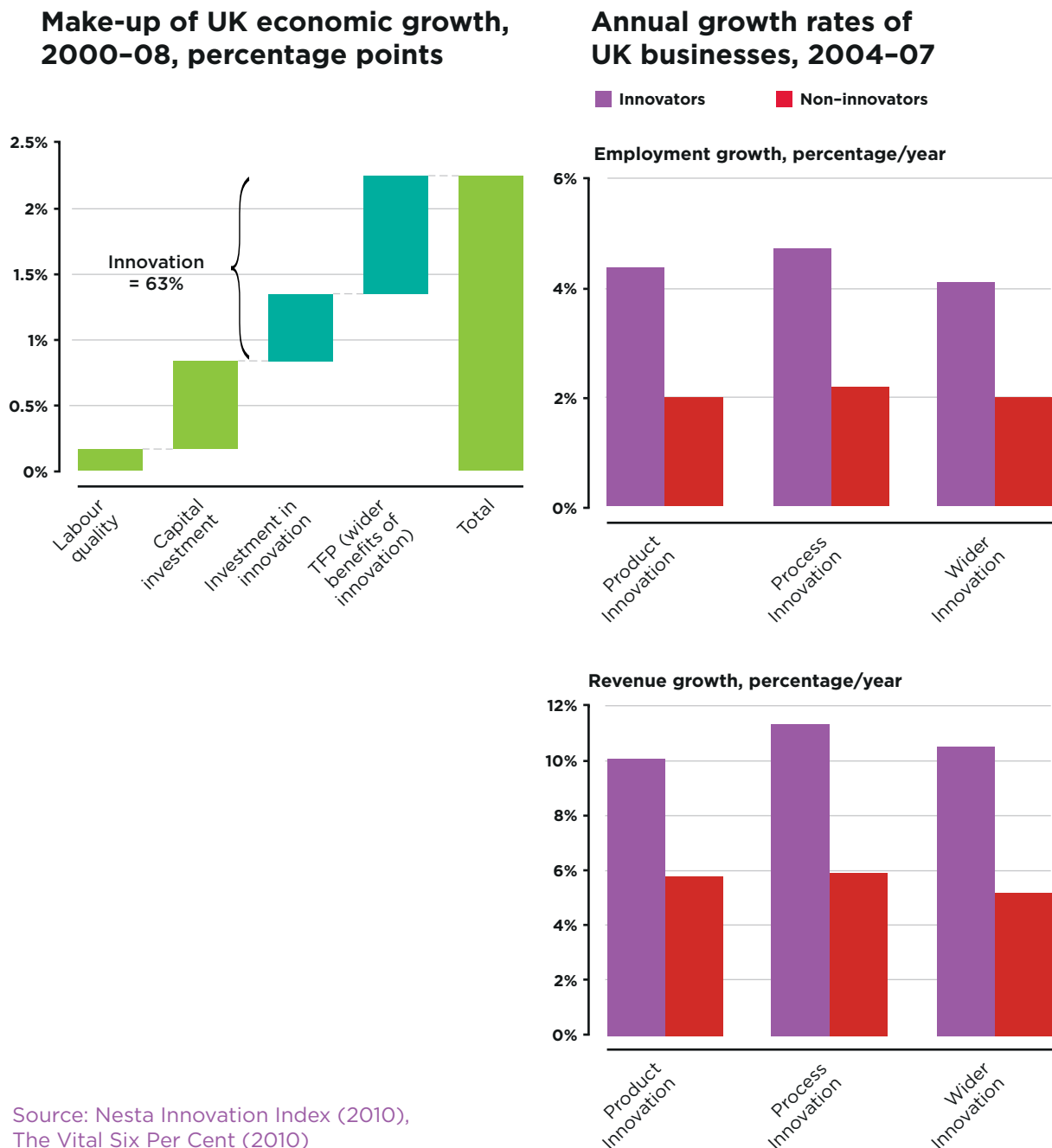
The ability to turn ideas into useful new products, services and ways of doing things is the wellspring of prosperity for any developed country.² Decades of research show that some countries, sectors and businesses are highly innovative and others are not.³ In the UK 63 per cent of productivity growth in the last decade came either directly or indirectly from innovation (see Figure 1).

The companies that invest most in innovation tend to grow faster than ones that don't; and the countries that invest most in innovation do as well. The link between investment and results isn't automatic — and much depends on how investment in innovation is organised. But it's no coincidence that the world's most dynamic economies and the country's most exciting businesses are also major investors in innovation.

Nor is it a coincidence that many of the nations doing best today have articulated a clear vision of where they think their future wealth and jobs will come from. Without falling into the trap of over-prescriptive plans, countries as diverse as Korea and Finland, Israel and Singapore have sustained a mood of optimism and possibility through the crisis, and given business a sense of the future gains that make investment today worthwhile. By contrast the UK, along with other parts of Europe, has seen its horizons shorten.

Unfortunately the current economic debate in the UK has pushed innovation and questions of long-term growth to the margins. There is an implicit belief that thinking about them is irrelevant or even unhelpful, and that we should worry about the long term either not now, or not at all.

Figure 1: Benefits of innovation



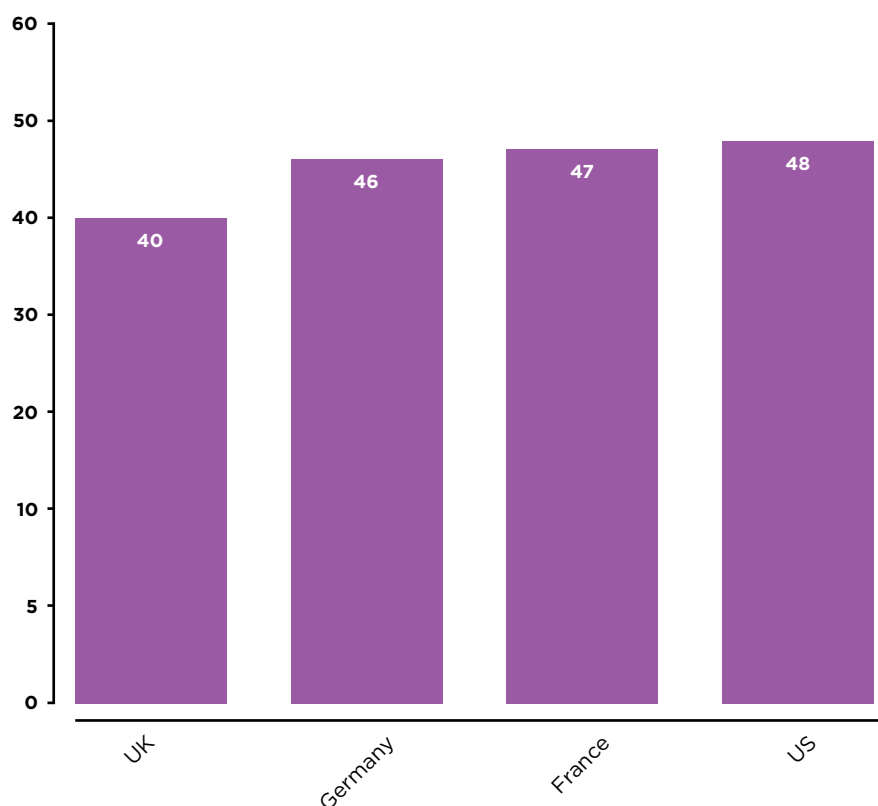
Some of the more vocal advocates of austerity embrace a fatalistic and passive attitude to the need to deleverage. They simply hope that growth will come when it comes,⁴ perhaps as the result of a sudden surge of entrepreneurial energy. Equally, some proponents of Plan B insist not only that stimulus is necessary, but that structural reforms are unnecessary and that the economy before 2007 faced no real problems other than those caused by the banking crisis.⁵

Why does long-term growth matter?

Yet any coherent economic strategy has to address the question of innovation and sustainable growth. In particular, this means working out the crucial roles played by government as a funder of R&D and adoption, by finance in enabling firms to innovate new technologies, and by businesses and entrepreneurs in developing the goods and services of the future.

- a. **The UK's productivity gap.** For many years, the UK has been less productive than other rich economies, in particular the United States and Germany. This gap grew smaller in the decade before the financial crisis, but seems to have reopened since. Moreover, there is cause to think that a small but significant proportion of the productivity gains Britain experienced in the years before the crisis will prove hard to replicate in the future. The retail sector, which was a major source of productivity improvements in the pre-crisis decade, is likely to be hit by lower consumer spending as households pay down debt. And manufacturing may not be doing as well as it appears: American research suggests that manufacturing productivity in rich countries is lower than we thought, because of a failure to account properly for offshoring. This effect may mean that, for the US, half the real output growth in manufacturing from 1997 to 2007 was illusory.⁶

Figure 2: Labour productivity levels, GDP per hour, average over 2000–2010 (2005 \$ PPP)



Notes: Analysis based on OECD data (extracted on 28 October 2011 from OECD Stat). GDP from GDP database, hours date from OECD productivity database. GDP is US \$, constant prices, PPP, OECD base year (2005).

- b. Changing economic realities.** In a world where the real economy is changing radically, continued productivity gains require that businesses learn to do things in new ways. That requires investment in the various categories covered by Nesta's Innovation Index — from software to organisational development. Many economists from across the political spectrum have argued that the economy is going through a period of profound change, with the deeper deployment of network technologies, 'decarbonisation' of production and consumption and the continuing shift of production from manufacturing to services and from the developing world to the BRICs. There is little consensus on the precise forms these changes will take: the scenarios range from Carlota Perez's vision of a world transformed by the deployment of new technologies, to Joseph Stiglitz's view that the shift of employment from manufacturing to services is causing epochal structural upheavals (see table below).⁷ But in almost all of these theories, successful adaptation will require a greater capability for innovation.

Argument	Who has made it	What is the argument?	So what?
'The Great Stagnation'	Economists Tyler Cowen and Michael Mandel, Sci-Fi author Neal Stephenson, investor and entrepreneur Peter Thiel	Innovation has been slowing down since the 1970s. Future breakthroughs will be less impactful and harder won than past innovations	Economic growth will be low in the future. There is not much we can do about it, except possibly incentivise scientists and entrepreneurs
'The Second Economy'	Complexity expert Brian Arthur, economists Erik Brynjolfsson and Andy McAfee	Innovation is speeding up rapidly, as ICT gets deployed through the whole economy. Expect to see massive disruption in the next 20 years	'Technological unemployment' will become widespread, as people are made redundant by machines
The Great Depression II	Joseph Stiglitz and Bruce Greenwald	We are seeing a repeat of the Great Depression. Stiglitz and Greenwald argue the Great Depression represented the growing pains of an economy shifting from farming to factories, and that the same is happening now as jobs move from manufacturing to services	The economy can only thrive if we generate high quality services jobs
The sixth industrial revolution	Innovation scholar Carlota Perez	History involves a series of technological revolutions; each goes through a freewheeling 'speculative' phase followed by a phase of consolidation, with a crisis in between. The ICT revolution is moving from the first to the second phase now	We need a Keynesian state to help roll out the new technologies developed in the past 20 years

The ‘real economy’ is changing: some arguments by economists and others

This is also a reminder that economic change does not always happen gradually. The deployment of new technologies can herald rapid shifts in how the economy is organised (consider the fate of record shops, publishers or video rental stores in recent years); the effects of climate change and demographic change may both involve tipping points rather than steady deterioration. Whether the UK can innovate enough may make the difference not between slightly better and slightly worse outcomes, but between prosperity and calamity.⁸

- c. **The long term and the short term are linked.** Several authors have shown the links between good microeconomic policy that supports long-term growth, and fixing the short-term macroeconomic issues. Raghuram Rajan, a longstanding critic of the American financial system, argued that America’s inability to innovate and create good jobs led to excessive borrowing and helped cause the financial crisis. The corollary of this is that a sustainably productive economy is less likely to fall into banking crises or other macroeconomic calamities in the future.⁹ Gregory Tassé, an economist specialising in innovation, has argued that without improving the innovation system, stimulus spending or quantitative easing will be diverted to unproductive uses and so will not translate into economic recovery.¹⁰
- d. **Good growth.** Any intelligent society will want to prioritise some kinds of growth and restrict others. Not all innovations are desirable. Intensive debates about everything from gambling and pornography to out-of-town shopping and windfarms are signs of a healthy democracy. But there are also major potential advantages for countries which can accelerate certain kinds of ‘good growth’ and be in a better position to export goods and services. Philippe Aghion has argued that encouraging the development of green technologies requires focused innovation policy because so many industries are currently locked-in to energy-intensive business models.¹¹ Rising demand for healthcare and wellbeing (already the largest sector in every developed economy, and almost certain to grow as a share of GDP) is another example, putting a premium on innovation in these areas. Rather different arguments apply to the role of the financial services sector, which has proven highly profitable for many innovative businesses, but has generated colossal costs for society, which has had both directly and indirectly to cover the cost of ill-considered risks. Orthodox economics lacks tools either for assessing the value of different sectors and firms when uncertainties are so great, or for assessing the nature of the value they create and destroy (and therefore tends to default to simply saying “leave it to the market”). But policymakers can’t help but make judgements about the long-term gains and potential losses associated with different industries, and the relative priority for different types of innovation.

So thinking seriously about innovation and the long-term structure of the economy is essential if we want to deal with long-term productivity problems, respond to possibly epochal shifts in the way the world’s economy works, and achieve more desirable patterns of growth.

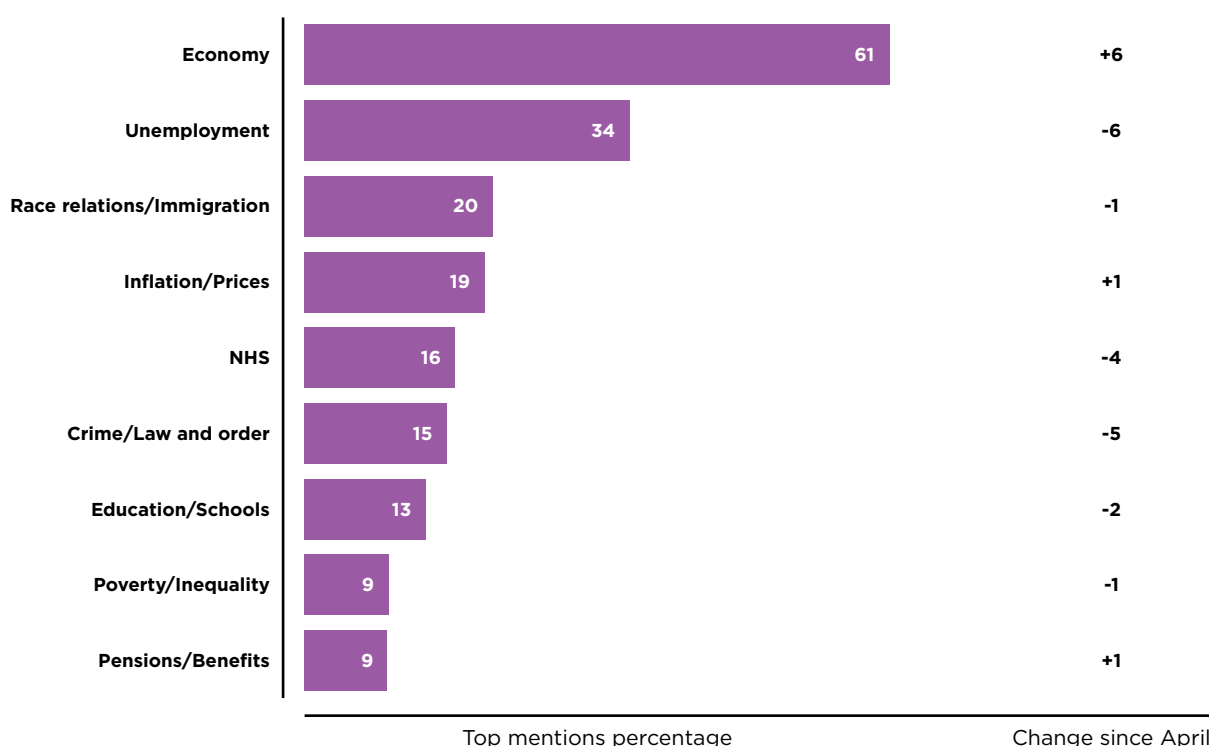
Why now?

The other objection to thinking about innovation raised by supporters of Plan A and Plan B is one of timing. They may accept that innovation is important. But they argue that we should turn our attention in this direction only once we have stabilised the macroeconomy.

This is also mistaken. There are three reasons why it will pay to act now.

1. Solving the long-term problems requires the same type of political capital that solving the short-term ones does. People are more willing to make sacrifices or change behaviours when faced with a crisis. Economic growth is a top priority for voters in the UK now. They want politicians to set out a roadmap for long-term growth and they will be willing to give up some current consumption if they can see a future pay-off. The niceties of macro versus microeconomic reform are largely irrelevant to them. But they are well aware that the UK's future prosperity depends not just on cuts or stimulus but also on our ability to innovate the next generation of computers or cars, materials or supermarkets.

Figure 3: Top concerns of UK voters, May 2012.

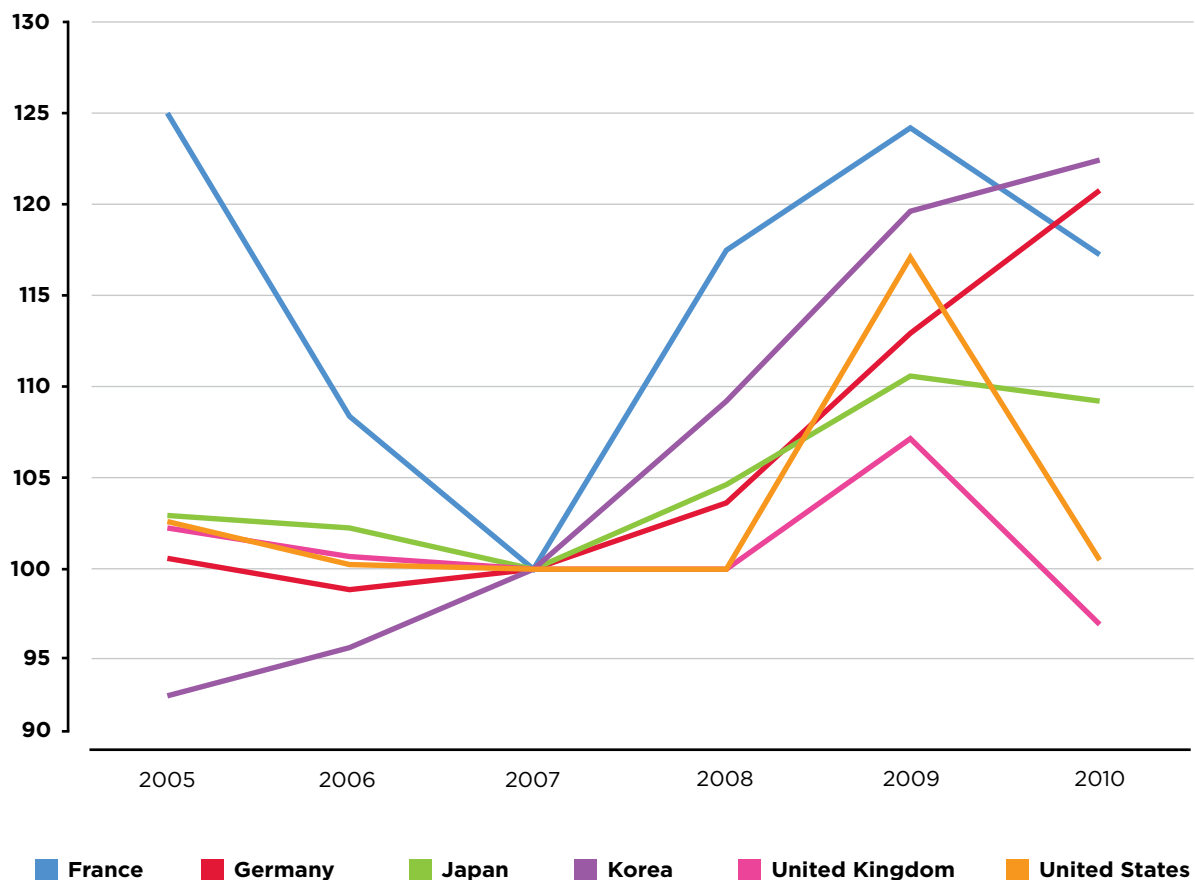


Base representative sample of c.1,000 adults age 18+ each month, interviewed face-to-face in home. Source Ipsos MORI

What's more, from a political point of view, it makes sense to address long-term issues at the same time as short-term ones. Supporters of economic stimulus who have argued that structural reform is unnecessary have needlessly weakened their case by allowing proponents of austerity to claim long-term reform as their own. Even if this were acceptable economics, it looks like bad politics.¹²

2. Under some circumstances, short-term policy can help stimulate innovation in the longer run. Stimulus spending can be invested in those types of infrastructure that do most to increase innovative capability, from broadband to smart grids to housing in overcrowded innovative clusters. Quantitative easing can be structured in ways that improves the flow of finance to growing innovative businesses. If short-term and long-term issues are dealt with sequentially, these opportunities for a double dividend are more likely to be missed.

Figure 4: Government budget outlays or appropriations on research and development. (Weighted by size of economy, 2007 = 100)



Source: OECD

- Finally, we can't ignore competitiveness. If domestic demand continues to be depressed, growth will depend on our ability to do better in export markets. But as other countries invest more in innovation and technology, we risk a further erosion of our competitive position, both in goods and services. Figure 4 shows that other developed economies responded to the crisis of 2008 by investing more in research and technology, and that they did so to a greater extent than the UK. Amongst these countries, the UK is the only one whose R&D budget was lower in 2010 than in 2007.

Postponing policy decisions increases the chance that other countries will jump ahead. This has happened before. In the past decade, the UK lost a commanding lead in the emerging plastic electronics sector as Germany and Russia pursued an aggressive industrial policy in the area, which Britain's government was not able to match. The result was that Plastic Logic, a UK-based leader in plastic electronic displays, established its production facilities in Dresden and Zelenograd rather than in the UK.¹³ Graphene, the wonder material developed in the UK whose discoverers have received knighthoods and generous government grants in the past year, is also the focus of attention and subsidy from many other governments. None of the top 20 organisations holding patents relating to graphene is British.¹⁴

So a focus on innovation and the long-term productivity of the economy is important, and it is important now. The crucial choices cannot be postponed. In the next section we turn to look at the state of innovation in the UK, and identify the priority areas for action.

2. THE UK'S INNOVATION OPPORTUNITY

Speak to an optimist and to a pessimist and you will hear two remarkably different stories about the state of innovation in the UK today.

For an optimist, the UK is an innovation hot-spot. It plays host to many world-beating established businesses. Manufacturers like Rolls-Royce, Renishaw and GKN export advanced products around the world. Chips based on ARM Holdings' designs sit inside most of the world's mobile phones and tablets. Our life sciences sector includes two of the world's top ten pharma companies. The UK also has thriving start-ups and smaller businesses, from the digital media and creative businesses of east London, Soho, Manchester and Edinburgh, to the life science clusters of Cambridge and Dundee. All this is underscored by internationally renowned research universities and a knowledge base that attracts the rest of the world: more foreign funded R&D takes place in the UK than in any other country.

JAMES KING-HOLMES/SCIENCE PHOTO LIBRARY



1. Andre Geim, Graphene

JOHAN PERSSON



2. NT Live

COURTESY OF DYSON



3. Testing the Dyson bladeless fan in the EMC Chamber

COURTESY OF GNODAL



4. Gnodal semiconductor



5. Government open data website GOV.UK

COURTESY OF INCREDIBLE EDIBLE TODMORDEN



6. Mini-garden made from an old dinghy at Todmorden High School

Our creative industries are world-leading¹⁵ and range from aesthetic innovators like Damien Hirst or London's fashion designers to tech-savvy industries like visual effects and video games.¹⁶ This is underpinned by high quality public institutions that support innovation, including excellent art and design colleges, and the BBC, which trained generations of advertising, film and TV successes, was ahead of the curve on computing in the early 1980s¹⁷ and on the internet in the early 1990s, to the country's benefit.

WHAT IS INNOVATION?

Innovation is a very widely used, and overused, word. Many definitions have been provided over the years by the OECD and other organisations. But it is worth setting out a few reminders of what innovation is, and what it is not.

Innovation is not the same as invention, creativity or entrepreneurship, though it overlaps with these. Broadly speaking, innovation is the process by which new ideas turn into practical value in the world: new products, services, or ways of doing things. It is not just about new technologies or about scientific R&D. Nesta's Innovation Index shows that R&D represents only 11 per cent of what businesses invest in innovation. Budget air travel is just as much an innovation as a new aircraft. Apple is a very innovative company, but spends relatively little on R&D.¹⁸ Its strength is in design, and the integration and adaptation of others' inventions. The retail sector can be very innovative, but does almost no R&D. Most technological innovations depend on complementary non-technological innovations to achieve commercial success, as anyone who owned an early, pre-iPod MP3 player, with a clunky interface, limited ability to buy music and unattractive design can verify.

Innovation happens in civil society and government as well as in businesses. Hospices, organic food, credit unions, social investment, and websites like Freecycle are just a few examples from civil society. Online tax returns, Oyster cards, Citizen's Service, NHS Choices and Family-Nurse partnerships are just a few examples involving government.

Innovations are recursive, like Jonathan Swift's fleas: all innovations contain within them other, older innovations, and often the re-combination of existing innovations gives rise to radical breakthroughs.

The benefits of innovation are widespread, and only a small proportion of them accrue to the innovator. Economists refer to the 'spillovers' from innovation, a recognition of the fact that many innovators reap no returns at all from the time and money they invest in innovation, and even successful ones often create much more value for their competitors, customers and unrelated businesses than for themselves. Consider windows-based computer displays. They were pioneered at great expense by Xerox, who made virtually no money out of the ground-breaking Alto and Star computers. Apple refined them and did well from the Lisa and Macintosh lines, but not well enough to avoid serious financial trouble in the mid-1990s. It was Microsoft that finally took the graphical user interface worldwide, making billions from the Windows operating system.

Innovation often brings more benefits to its adopters than to its creator. Businesses that developed and built computers often got rich, but the value they created was dwarfed by the value created in the wider economy by the adoption of computers and the improvements in efficiency that they inspired.

The business and financial services sectors also provide fertile ground for innovation. They have continued to grow in terms of both turnover and jobs in the last two years in part because of their appetite for continuous innovation. In fields from law to architecture and design to fund management, UK businesses punch above their weight: we are the world's largest exporter of services,¹⁹ and this part of the economy was a major contributor to productivity in the last decade.²⁰ This kind of innovation — the ability of the economy as a whole to adopt innovations such as ICTs and new business practices, which is 'hidden' from traditional indicators — has historically been strong in the UK.

All these strengths are bolstered by a culture that has a long tradition of openness to innovation, of entrepreneurship and experiment,²¹ stretching back through Babbage and Lovelace and Brunel, to the ironmasters of the Industrial Revolution, the Lunar Society, the Radicals and the cooperatives.²²

That there is scope for optimism on so many fronts might have come as a surprise 35 years ago. In the late 1970s, the UK was at the tail end of several decades of declining relative productivity, and seemed destined to continued decline. Innovative dynamism appeared to have gone elsewhere — to Japan and Germany, California and Taiwan. Yet perhaps against the odds the UK has maintained its vigour, and attracted in thousands of innovators from the rest of the world.

That's the optimistic view. The pessimists argue that the UK's innovation performance is nothing like as strong as the description above would suggest.

According to this view, UK innovation is embattled. The UK's manufacturing sector is being squeezed between efficient exporters like Germany and Finland on the one hand and the giants of the developing world on the other.²³ Large, innovative companies are investing elsewhere (witness the closure of Pfizer's Sandwich research centre²⁴) or are being sold to foreigners (for example, the sale of Autonomy to HP). Our world-class researchers produce great ideas, but other countries profit from them,²⁵ from the World Wide Web to plastic electronics.

The UK's creative industries are full of brilliant ideas and talent, but the value they create is captured by foreign intermediaries, from games distributors to film producers to search engines.²⁶ The financial sector is too short-termist and will not back the risks inherent in innovation,²⁷ or needed to grow innovative businesses.²⁸ And our entrepreneurial spirit is being held back by deep-seated cultural factors, such as aversion to risk,²⁹ or excessive regulation,³⁰ or the lure of the City of London³¹ that pulls the best science graduates away from direct involvement in useful innovation to secondary activities in hedge funds, private equity or derivatives.

A more balanced assessment

The truth lies somewhere in between these views. The UK's innovation system has considerable strengths, and a slew of great companies and institutions. The UK can make a good claim to have invented innovation in its modern sense — the scientific method in the eighteenth century; the networks of engineers and inventors that powered industrial advance in the nineteenth century; the use of prizes to spur on inventors; not to mention social innovations as diverse as parliamentary democracy, universal healthcare and public service broadcasting. We have long had a healthy culture of argument and dissent, creative radicalism and inventiveness.

But if we want to take advantage of the opportunities on offer in the next decade from new technologies, new markets, and new ways of doing things, we have to face up to the gaps, the failings and the many ways in which institutions and markets aren't well designed to make the most of new ideas. Above all, we need to acknowledge that as things stand, we are not making the most of the UK's potential. The stock of innovative ideas in the UK is not the limiting factor. From translating breakthrough research into new industries, to making the most of the UK's rich tradition of independent invention, to backing social innovation in communities and the UK's creative industries, there is scope to do more. It is hard to calculate precisely the size of the gap, but some of the analysis that follows suggests we may be under-investing in innovation to the tune of £38 billion a year. The rapid development of countries like Taiwan and Korea from agricultural to advanced economies, or the transformation of cities like Pittsburgh and Cleveland from post-industrial decay shows that change for the better can happen relatively quickly where there is the will. In what follows we first consider what these opportunities are for the UK, and then we look at how well positioned the UK is to exploit them.

The prize: what innovation offers us

In the last few years, a few influential commentators have argued that the pace of global innovation is slowing down. These pundits are a diverse bunch, including Silicon Valley svengali Peter Thiel, the economist Tyler Cowen, and author and essayist Neal Stephenson. It's argued that the returns to investment in R&D are declining; the time taken to develop new drugs and technologies is increasing; and that all the 'low hanging fruit' of innovation have already been picked. That's why we still drive cars whose technology is rooted in the nineteenth century, and travel in aeroplanes built in the 1960s, and why the 1950s' technological visions of jet packs and colonies on Mars have not come to pass.³²

In our view, this pessimism is unwarranted. Although there are some signs of innovation slowing down in particular sectors (usually as a set of technologies reach maturity), the bigger picture is one of continuing advance. Three powerful forces explain our optimism.

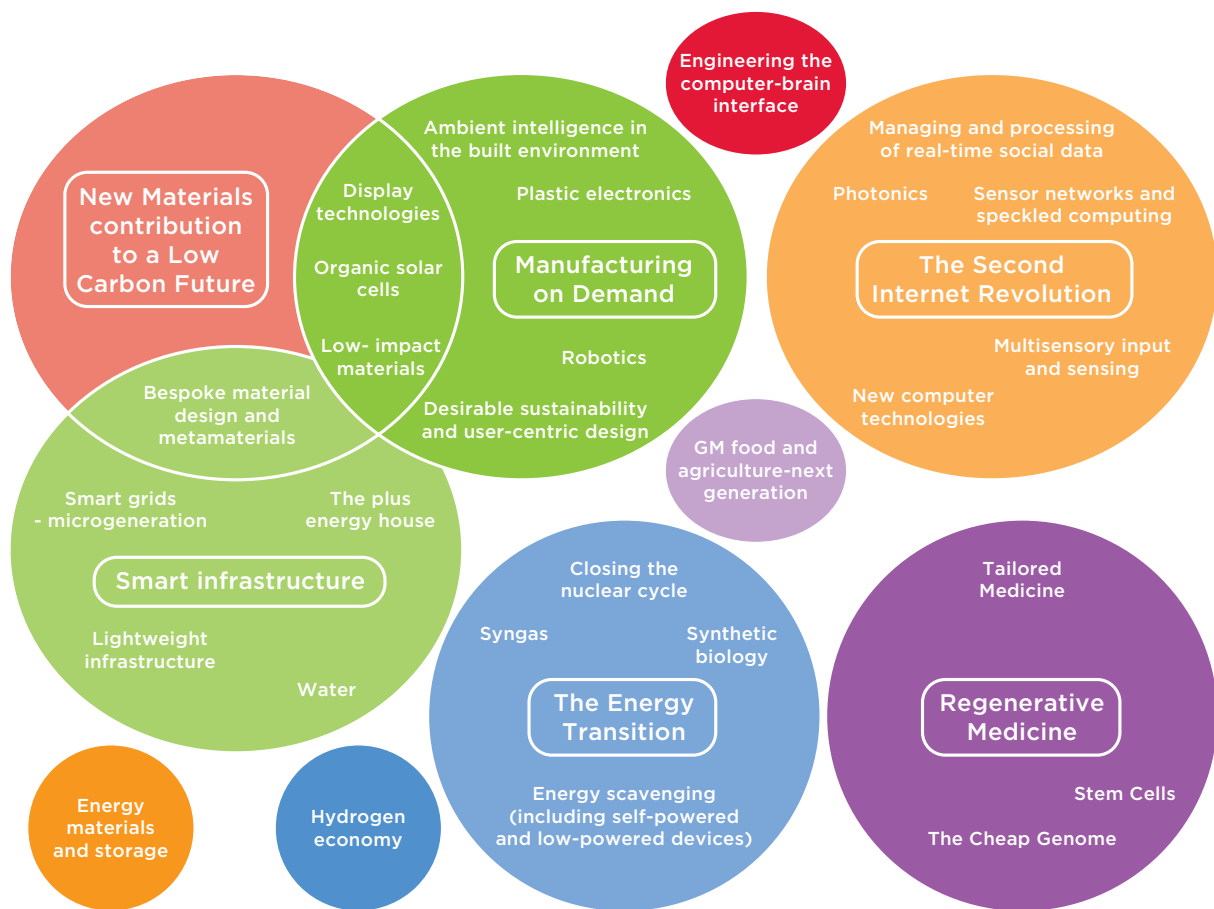
First, the continuing advance of information technology is showing no signs of slowing down.³³ Moore's, Metcalfe's and Gilder's 'laws', which predict that processing power, bandwidth and network connectivity will increase exponentially over time, appear still to be in full force. As a result we should expect a continuing flood of new products, services and systems opening up a dizzying range of possibilities. The ICT revolution has already changed the retail and logistics industries beyond recognition, shaping supply chains, customer expectations and business models. Through social media and mobile telephony it has changed the way many people interact. There is no reason that this kind of disruptive change should not affect the rest of the economy. Our healthcare system, for example, stands ready to be revolutionised by new technologies, through better gathering of health data and computer analysis of it,³⁴ through better mobilisation of the Internet and mobile platforms, and the intermingling of biology and digital technology. The financial services sector, which has already been transformed once by technology, between 1980 and 2010, could see a second revolution enabled by new information standards and technologies (as has happened, for example, in Africa where much banking is now organised on mobile devices).³⁵ Education too is ripe for radical change: ventures like Udacity and the Khan Academy are suggesting a very different model for how education could be delivered, and one that will have dramatic consequences for universities, schools and learners (a trend discussed further in section 4, recommendation 11).

Brian Arthur, who has thought more profoundly about technology than most, argues that these changes herald the rise of a ‘second economy’ of data and intelligence sitting alongside the first economy, whose implications will be as profound as the first industrial revolution.³⁶ Big data,³⁷ collaborative consumption,³⁸ self-driving cars, the Internet of things, and cloud computing³⁹ all look like plausible early manifestations of such an economy. Erik Brynjolfsson, one of the world’s experts on the impact of ICT on productivity, borrows Ray Kurzweil’s analogy of the ‘second half of the chessboard’ to argue that the effects of ICT are only just beginning to be felt.⁴⁰

The huge potential of ICT is just one aspect of innovation. Other technological developments, from new advances in life sciences to the emerging disciplines of nanotechnology could have just as large an effect. Life sciences and biotech have so far not delivered on the expectations of ten or 20 years ago. But there are good reasons to believe that although the pace of change was misjudged, the scale of likely change was not. It is possible that over the next few decades, advances in genomics and biotechnology, and fields such as neuroscience, really will lead to a new golden age of medicine, matching the glories of the last golden age that lasted from the 1940s to the 1970s and saw the discovery of everything from antibiotics and chemotherapy to cortisone and heart transplants.⁴¹ During this phase it may be the ability to integrate different technologies that will be critical — from genomics and proteomics to bioengineering. New materials, including graphene and other carbon structures, may lead to dramatic breakthroughs in manufacturing.⁴² If we are to avert severe global warming, we must hope that significant system-wide innovations in reducing carbon emissions and producing low-carbon energy (or failing that, geo-engineering) come to pass.

Social innovations also offer great potential. The wastefulness, in both human and financial terms, of the way we run our healthcare systems, the way we care for old people, and the way we treat the most excluded in society, is huge. The right social innovations could unlock as much value as many great social innovations did in the nineteenth century, from public sewers and health programmes, to mutuals and cooperatives, unemployment insurance and modern nursing care. Indeed without vigorous social as well as technological innovation, the megatrends of ageing and climate change are likely to slow growth down and fuel social conflict. And the two are likely to cross-fertilise: Wikipedia, one of the wonders of recent years, is as much a social innovation as a technological one. During past periods of rapid change, like the mid-to-late nineteenth century, radical social innovation and reform proved essential for the full deployment of technological innovations, from industrialisation to the railways. The same is very likely to be true as the world gropes for a new approach to growth.

Most of these innovations will create benefits not just for those who develop and commercialise them, but also for those that can effectively deploy them, and build new services and businesses around them. The UK has the technological capabilities to play a role in many of these areas. Figure 5 summarises research conducted by the UK government’s Foresight office to identify important areas of technology where the UK had research and industrial capabilities.

Figure 5: Areas of technological strength and opportunity for the UKSource: Foresight Horizon Scanning Centre⁴³

The UK's innovation system

So how well positioned is the UK to make the most of possibly dramatic waves of innovation in fields as diverse as data and healthcare, new materials and energy? We certainly have many great strengths, some the legacy of two centuries on the forefront of science, industry and social creativity. But if we look at the state of our innovation system — the interplay of resources, people, ideas and markets in which innovation happens — much isn't working well. In what follows, we first consider at a high level the strengths and weaknesses of the UK's innovation performance, and then go onto identify some of the underlying causes.

What does the UK do well in terms of innovation?

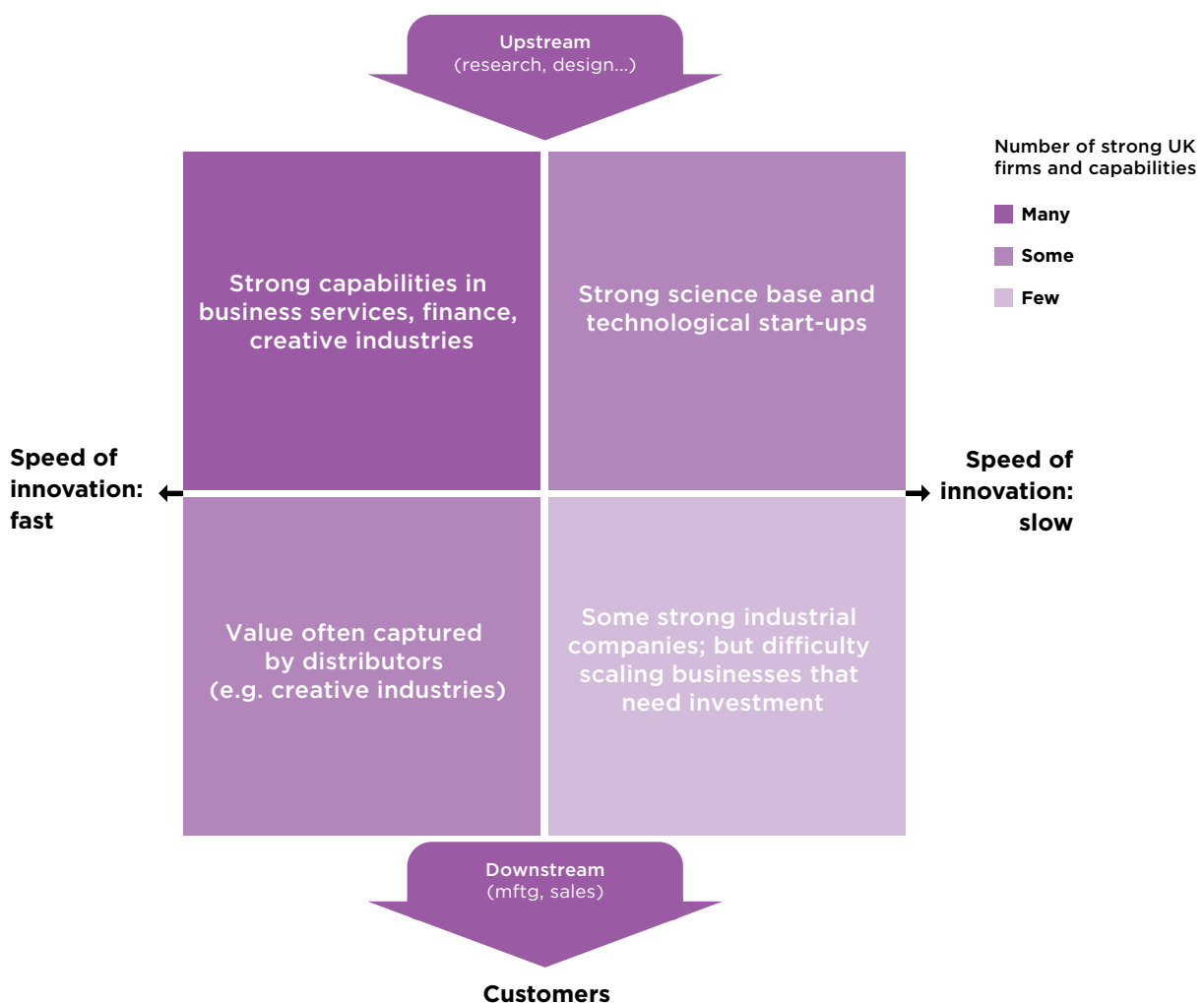
The complexity of the UK's economy makes it hard to quantify our relative strengths in innovation. But there is considerable agreement among business people, civil servants and commentators about the sorts of things the UK is better and worse at at.⁴⁴

Figure 6 sets out some of these capabilities, distinguishing between upstream and downstream activities, and those fields of innovation that are by their nature fast and

those that are slow. We've used this way of mapping innovation because it highlights crucial differences which often get missed when generalisations are made about the nature of innovation systems, or the nature of the modern economy. Some parts of the economy have become dramatically faster: the pace of adoption of new technologies like Twitter, or new lines in fashion. In these fields, innovation has to be fast and light too. Large, hierarchical institutions governed by detailed procedures are unlikely to thrive. But the idea that everything has become fast is misleading. Some parts of the economy are by their very nature slow, and may even be becoming slower, such as the development of new drugs; new weapons systems; or the design and deployment of new energy systems. These are typically areas where bringing new ideas into use is a longer and more complex business. Many investors came unstuck from accepting too uncritically promises of rapid deployment of new advances in biotechnology or cleantech. The correct conclusion is that any economy needs to be good at handling both fast and slow fields of innovation. It needs to be canny about the timescales by which ideas will turn into profitable new products and services. And it needs forms of finance that are suited to these very different timescales for turning ideas into revenues.

Many of the UK's traditional strengths lie in sectors where development cycles are relatively fast and capital intensity low. In these sectors, from fund management to fashion and from animation to architecture, we often possess expertise in both the 'upstream' aspects of the business — design, new product development and research — and the 'downstream' aspects

Figure 6: Relative strengths and weaknesses in UK innovation



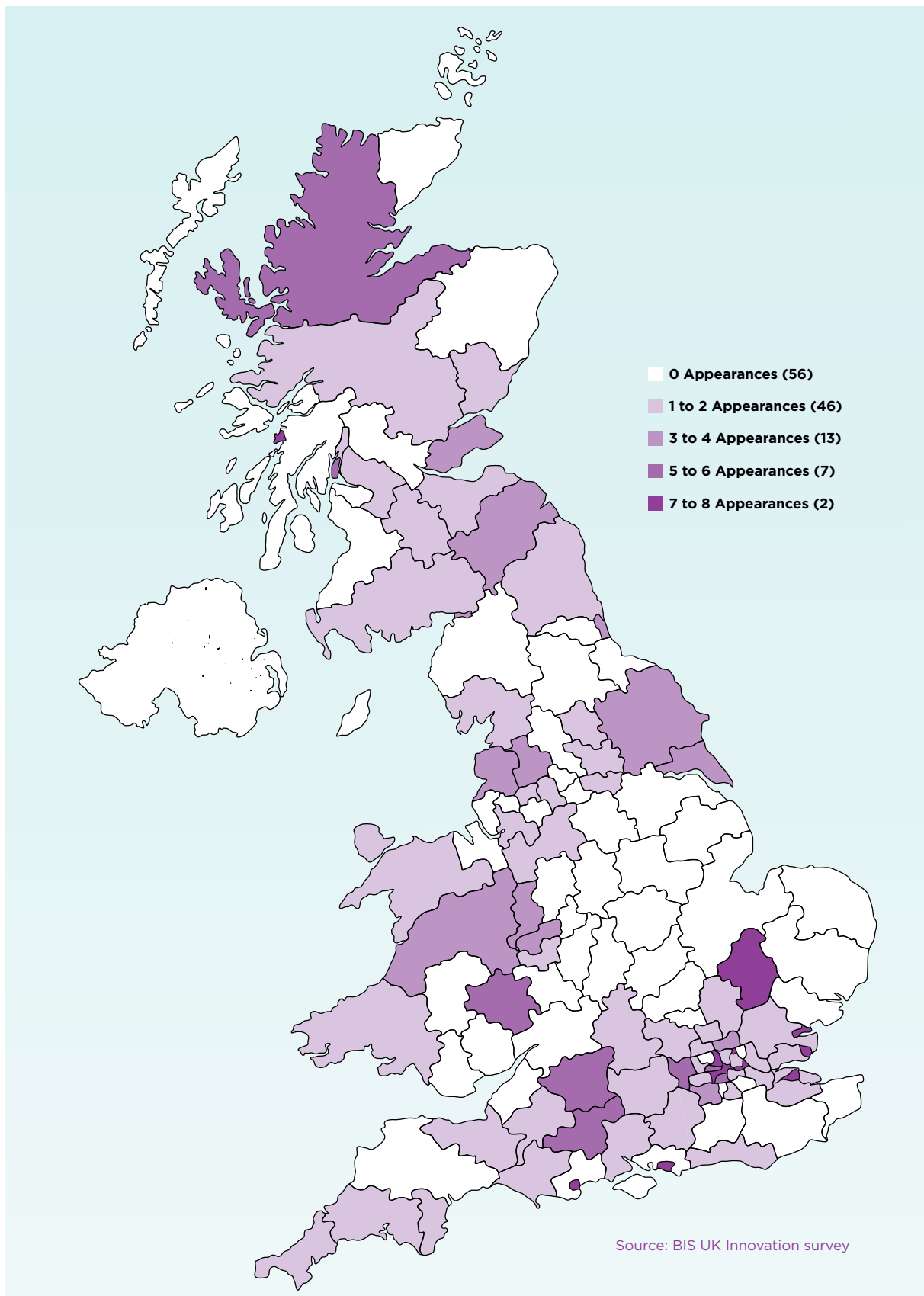
— production, sales, marketing. Creative content industries are a notable and growing exception, in that the final part of the value chain is frequently captured by non-UK firms (such as film distributors, or increasingly online platforms like Amazon and Apple iTunes).

As we move to the right of the chart, to industries that involve longer product cycles and require more capital, the value chains of UK firms become more fragmented and sectors where the UK is strong in both upstream and downstream activities become rarer. Businesses like Rolls-Royce, Renishaw, GlaxoSmithKline and the academic research that supports them, often cover the whole value chain from research to production, distribution and service delivery.

But the UK's high-tech manufacturing sector is proportionately smaller than that of Germany, Finland, Korea and other countries known for technological innovation.⁴⁵ In some cases, we see incomplete supply chains. The UK has some highly productive foreign-owned car plants, and a global reputation for R&D excellence in very advanced automotive controls (an expertise that draws on the UK's long involvement with Formula One, an interesting crossover between the manufacturing and creative industries). But for the most part, UK plants assemble cars designed elsewhere out of parts manufactured elsewhere.⁴⁶ Much of our scientific research is exploited in other countries, and 21 per cent of business R&D is paid for by foreign companies, while the UK generates relatively few high-quality patents per head.⁴⁷

The UK continues to perform well in attracting inward investment. But the closure of Pfizer's R&D facilities in Sandwich was a major loss to the UK's innovation system, and a symptom of ever more intensive global competition for hosting R&D. The sale of Autonomy to HP in 2011 reignited a longstanding debate about the UK's ability to grow great global firms, and concerns over the short-termism of Britain's financial institutions. Investors and entrepreneurs observe a tendency for British firms in high-tech and capital-intensive sectors to be bought by overseas businesses rather than raising finance to grow. (The industries in which this does not happen, including aerospace and pharmaceuticals, are those where government has over the years helped provide a relatively complete innovation ecosystem.) Sometimes overseas investors bring great benefits to the UK's economy: Britain's car industry became more efficient as a result of waves of foreign investment starting in the 1980s. But this is not always the case: at least some foreign investment involves little more than the purchase of UK businesses by foreign companies, a process that sometimes leads to the hollowing out of productive capacity. The semiconductor sector has seen rising stars like Element 14, Alphamosaic and Icera⁴⁸ bought by overseas chip designers which have in some cases transferred much or all of their operations out of the UK. This phenomenon has recently been explored by the ERA Foundation who argued it had weakened the productivity of the UK's manufacturing sector.⁴⁹ Policymakers frequently ask why there is no UK Google, and although this is a misleading question (most rich countries do not have a multi-billion-dollar internet company), the related issue of whether access to finance encourages British tech businesses to seek trade sales rather than expansion is a live one.

A final trend worth noting is how geographically uneven innovation activity is. This is true whether we look at narrow, technological indicators of innovation, such as high-tech employment, or much broader ones, such as the existence of clusters,⁵⁰ the abundance of high-growth businesses,⁵¹ or indices of absorptive capacity.⁵² This is significant from an economic point of view because we know that when it comes to innovation, place matters. So-called 'agglomeration effects' mean that innovative, dynamic places become more innovative and less innovative ones drift in the opposite direction. Innovative clusters can be powerful phenomena. We benefit from a few very strong attractors of innovation — but not enough to give confidence that the economy will create sufficient wealth and opportunities in the years to come.

Figure 7: Highly innovative businesses by area

The significance of all this is that there are many ways in which the UK could be a better place for innovation.

What could be improved?

There are three broad ways in which the innovative capacity of the UK can be improved:

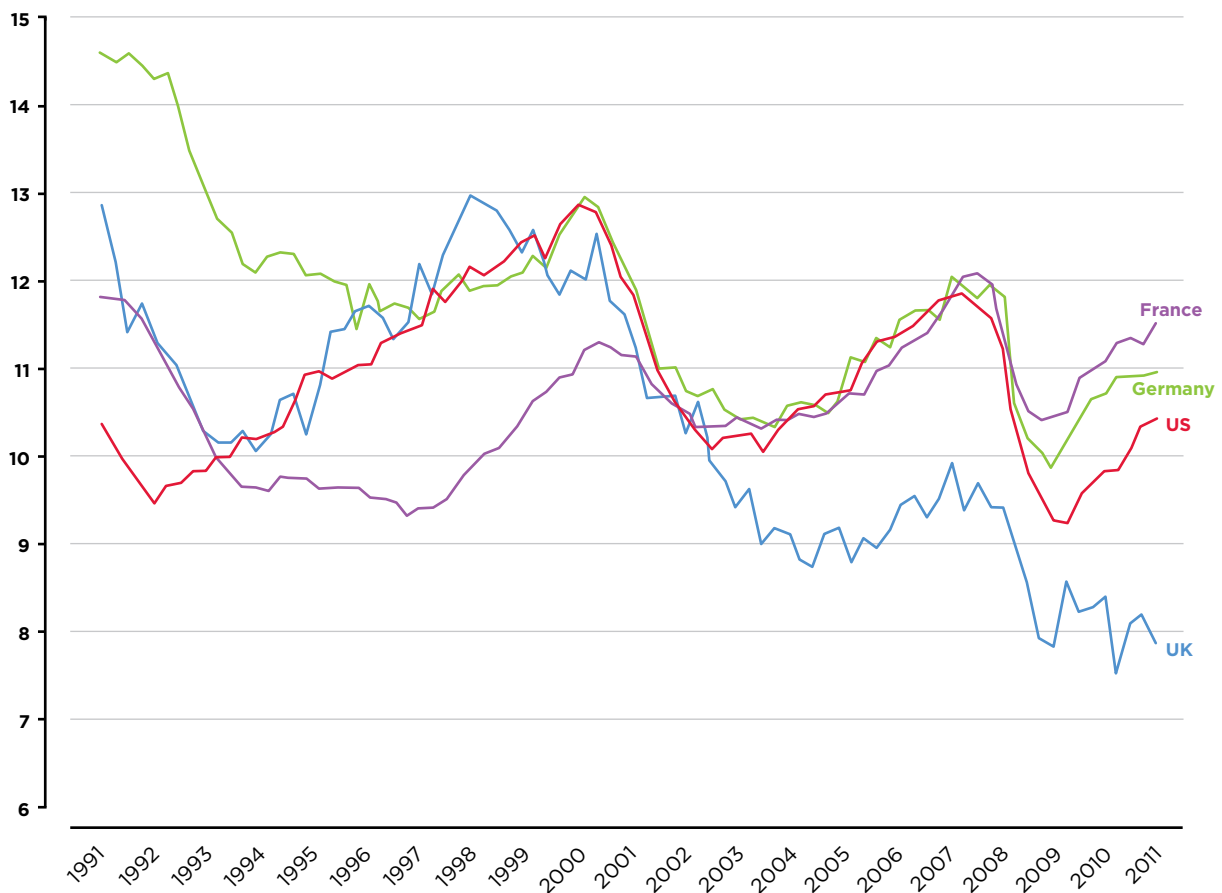
1. **Investment:** increasing how much the UK invests in innovation
2. **Systems:** upgrading the system of innovation so that these investments go further, including greater demand
3. **People:** changing the underlying cultures and skill sets to be more innovation-friendly

1. Innovation investment

Innovation requires finance of different kinds to take an idea from conception to large-scale implementation. The traditional assumption is that for every pound spent on research, three would be needed for development and ten for commercialisation. These ratios don't precisely apply to many contemporary industries — but it's broadly correct that finance is needed at successive stages in greater quantities, and with less scope for risk.

The UK has for decades invested less than other rich European countries at each of these stages. Some of this is the result of long-term structural issues that may be impossible to address. But in recent years, a more problematic phenomenon can be observed: new data collected by Nesta shows that investment by UK businesses has fallen further. This is a troubling sign for our innovative capacity, since investment in new equipment and ideas is vital for productivity and is a sign of an optimistic, dynamic business sector as the CBI has recently stressed.⁵³

This trend began well before the global financial crisis hit (a fall in investment in a recession would not have come as a surprise). As the price of capital goods, especially computers, fell in the 2000s, British businesses reacted differently from their counterparts in France, Germany and the US. Rather than taking advantage of lower prices to increase investment, they scaled back. Comparing investment against its historical levels and adjusting for the overall performance of the economy, UK firms' investment was one or two percentage points of GDP lower than would have been expected for most of the period between the dot-com crash and the credit crunch. This is not to say that all British firms stopped investing — some clearly have continued to do so. But the aggregate trends are concerning.

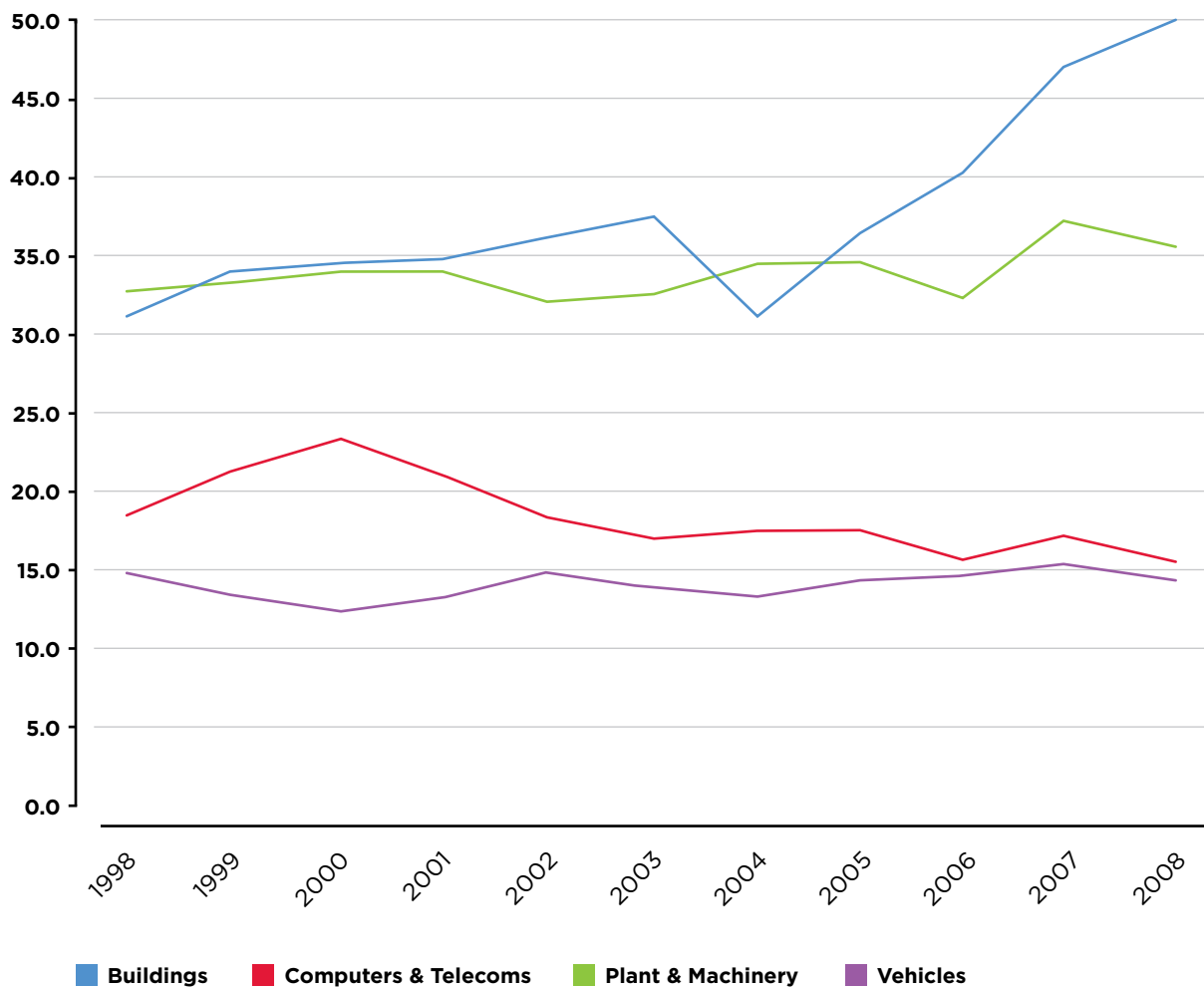
Figure 8: Investment in fixed capital, percentage of GDP, 1991-2011

Source: Oxford Economics analysis

This shortfall of investment represents around two percentage points of GDP per each year for over five years. This amounts to over £25 billion per year, a sum that would comfortably pay for a lavish shopping list of investments, including universal super-fast broadband, a smart electricity grid, and the High-Speed 2 rail link. It is also worth noting that while the US, France and Germany have seen investment rebound since 2009 (growing by between 1 and 1.5 percentage points of GDP), levels in the UK remain similar to their 2008 low point. Had UK business investment recovered to the same extent that it had in other rich countries, it would have been around £14 billion higher in 2011.

What is more, we now know that of the investment that was made in the pre-crash years, a rising share went into buildings and property rather than machinery or technological equipment. Given the steady rise of the property market from 2001-2008 and its subsequent fall, this suggests that at least some corporate investment was poor value for money.

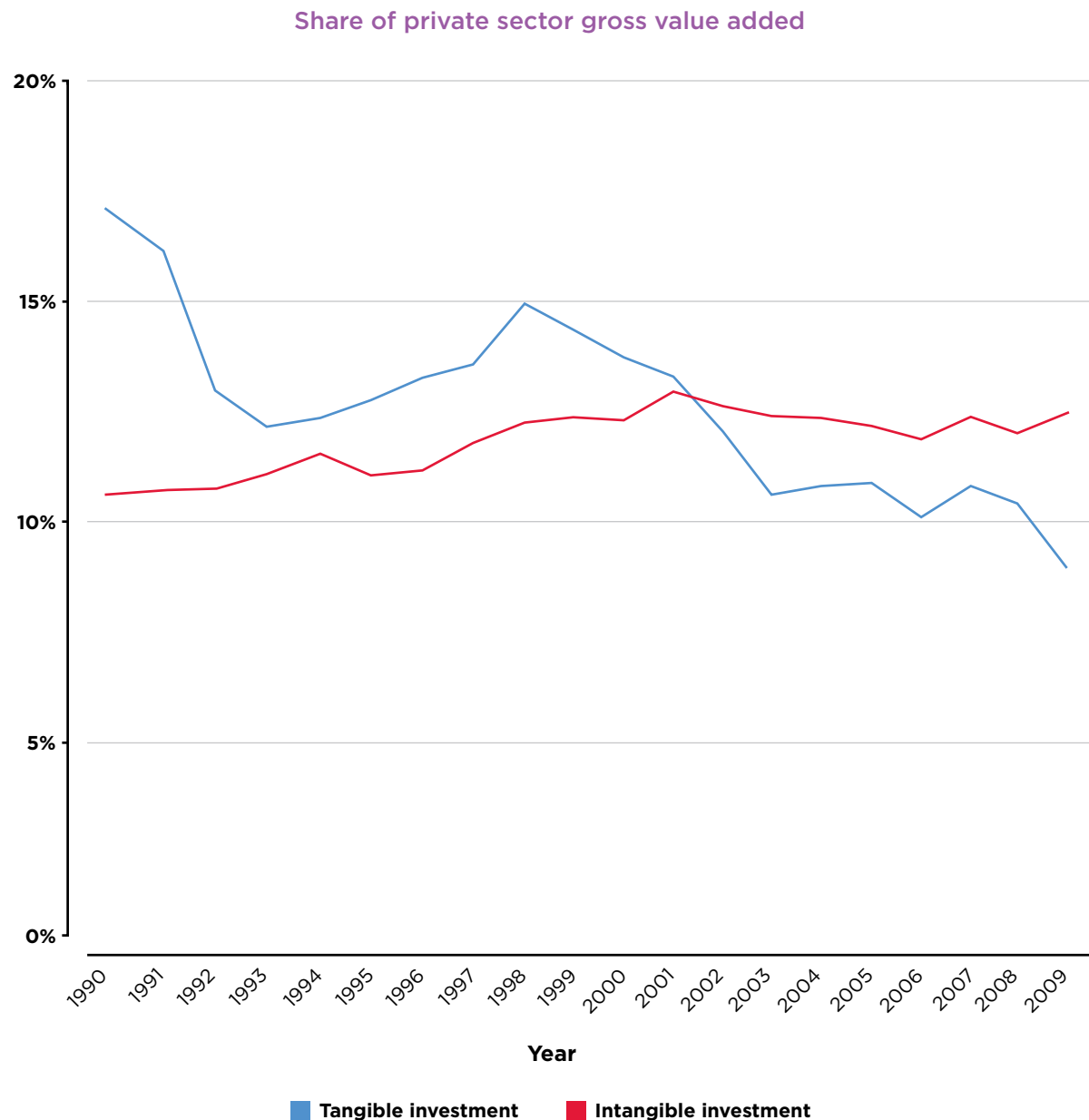
The story does not improve greatly if we consider intangible assets, that is, businesses' investment in everything from new ideas to training and skills. (These are increasingly

Figure 9: Investment in fixed assets by UK businesses, 1998–2008, £ billion

well measured through projects like Nesta's Innovation Index and the EU's INNODRIVE.) Intangible investment rose in most rich countries between 1995 and 2008, but in the UK, most of this rise occurred between 1995 and 2000, with intangible investment remaining constant as a proportion of national output for most of the 2000s.

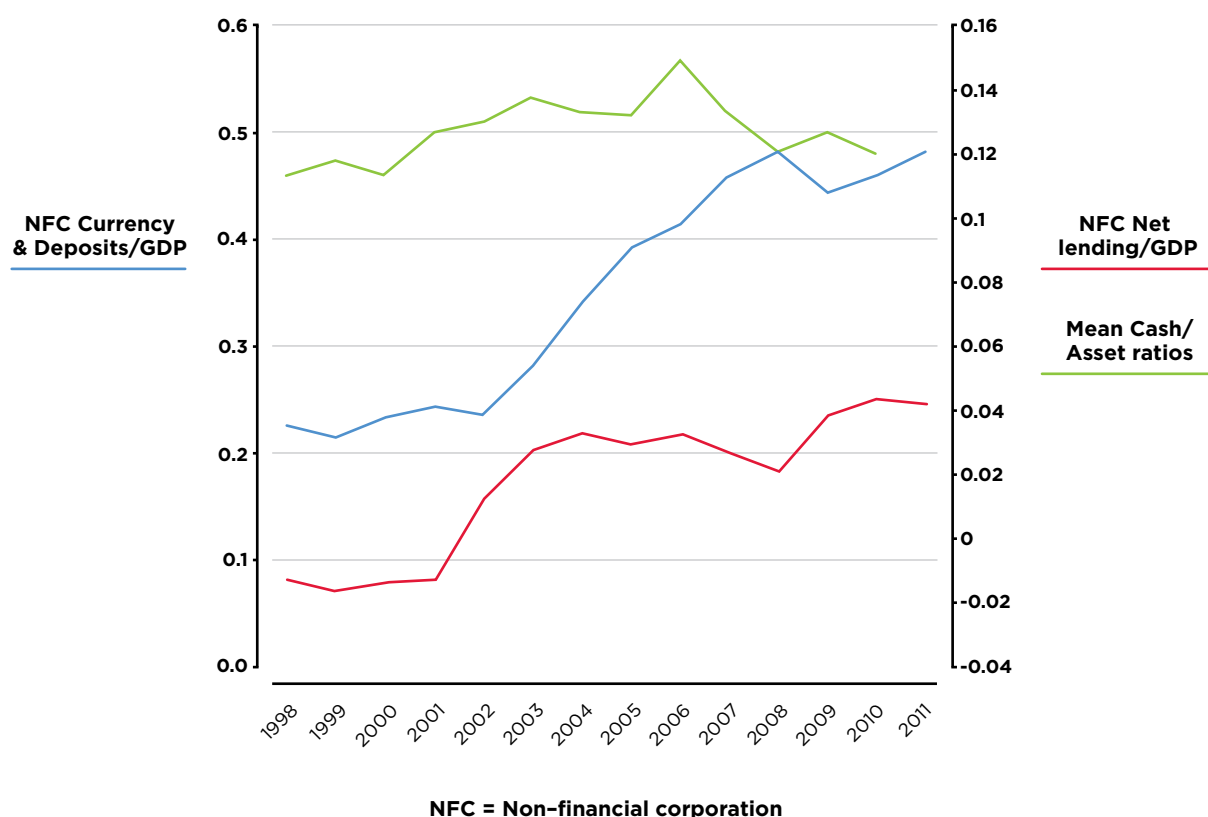
What happened to all the money? It seems that some of it was simply accumulated by companies. Bank of England figures suggest that UK companies' cash balances increased throughout the period, and had already reached post-war highs in 2003.⁵⁴ What's clear is that in aggregate there is no shortage of money: just a shortage of willingness to invest.

What is more, things have got considerably worse since the financial crisis of 2008. Nesta's Innovation Index shows a 5 per cent fall in innovation investment from 2008 to 2009; the Intangible Asset Survey conducted as part of the same stream of research suggests the fall has continued since then (and at best, has not recovered) — leading to a possible fall of around £24 billion a year, between four and five times what the UK government spends on backing university research. If we add this to the shortfall in tangible capital investment compared with other countries described above, the result is a £38 billion investment shortfall, a worrying sign of a lack of faith in the UK's future.

Figure 10: Total investment in intangible and tangible assets in the UK private sector

This apparent innovation strike owes something to how our financial system and our government finance innovation. Investing in innovation is risky and rarely yields quick results. The benefits often accrue not to the investor or the innovator but to competitors, customers or society at large. Businesses' investment in innovation also typically relies on others taking the really big risks in basic science, proving new technological concepts or acting as a lead market.⁵⁵ Accounting rules make it easier to capitalise physical investments than intangible ones such as R&D or design. This means a firm investing £1 million in a new building will appear more profitable than one investing the same amount in developing a new product. And pay for top executives in big firms often does little to incentivise, and much to disincentivise, investment in innovation.⁵⁶

Figure 11: Estimates of UK corporate cash: 1998-2011



Source: Office for National Statistics, Pinkowitz (2012)⁵⁷

This means that for businesses to invest in innovation, we need effective financial markets willing to finance risk and provide patient capital for innovation. We also need a government that is willing to invest alongside the private sector, funding basic risks that businesses are reluctant to fund, such as basic research, and the infrastructure for investment.

The UK financial system is one of the world's most sophisticated. But for the most part, it does not finance innovation in UK businesses. Nor does most investment in innovation by UK businesses depend on the UK's capital markets, as the chart below shows.

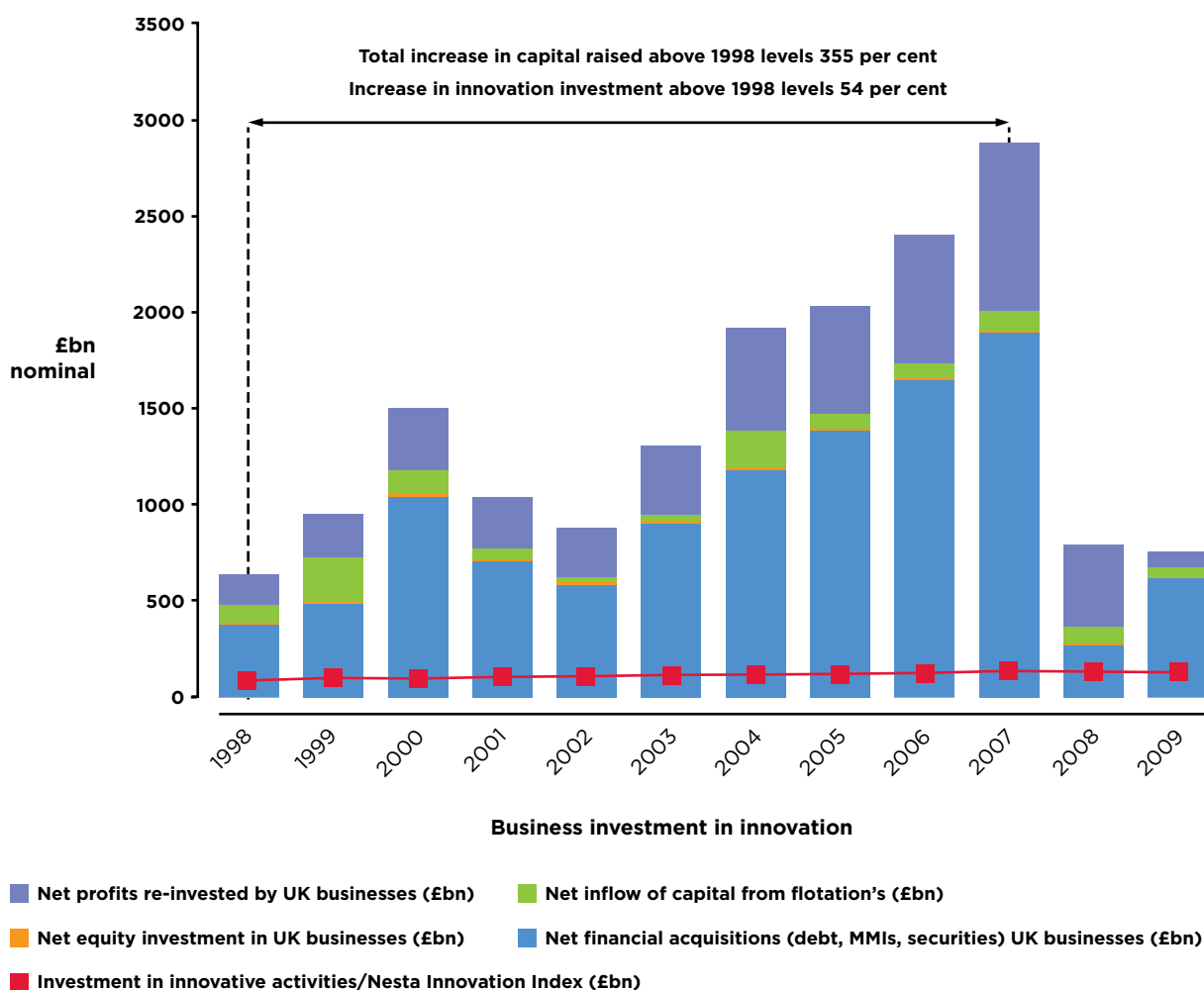
Indeed, there is increasingly clear evidence that equity markets systematically discourage long-term investment, particularly in risky endeavours like R&D or other forms of innovation.⁵⁸ Analysis carried out by Nesta and the Big Innovation Centre suggests that while UK capital markets raised £2.9 trillion of capital in 2007, an increase of 355 per cent over 1998 levels, business investment in innovation increased by only 54 per cent (Figure 12). This trend continues: by 2011, the ratio between the amount invested in innovation in businesses in the UK and the amount raised on capital markets reached its lowest point since 1997.⁵⁹

At the same time, public investment in innovation is also deficient. We saw earlier how countries like Germany and Korea, many of which already invested more in R&D than the UK,

had scaled up their investments in innovation much more rapidly following the financial crisis, as an important component of recovery plans. Public R&D spending will not on its own cause economic growth. But it is a necessary, if not sufficient, condition for sustaining a lead in many advanced industries.

There is also a broader problem with the way the government allocates the country's resources. Intuitively, some government spending increases the UK's capacity for economic growth and some does not, or does so only indirectly. No-one would argue that all spending should contribute to economic growth — better health and education are ends in themselves as well as means to other ends, and any civilised society looks after people in need, regardless of their potential productivity — nor that government spending should be indiscriminately described as investment to create a false impression of prudence.

Figure 12: The UK's capital markets and businesses' investment in innovation



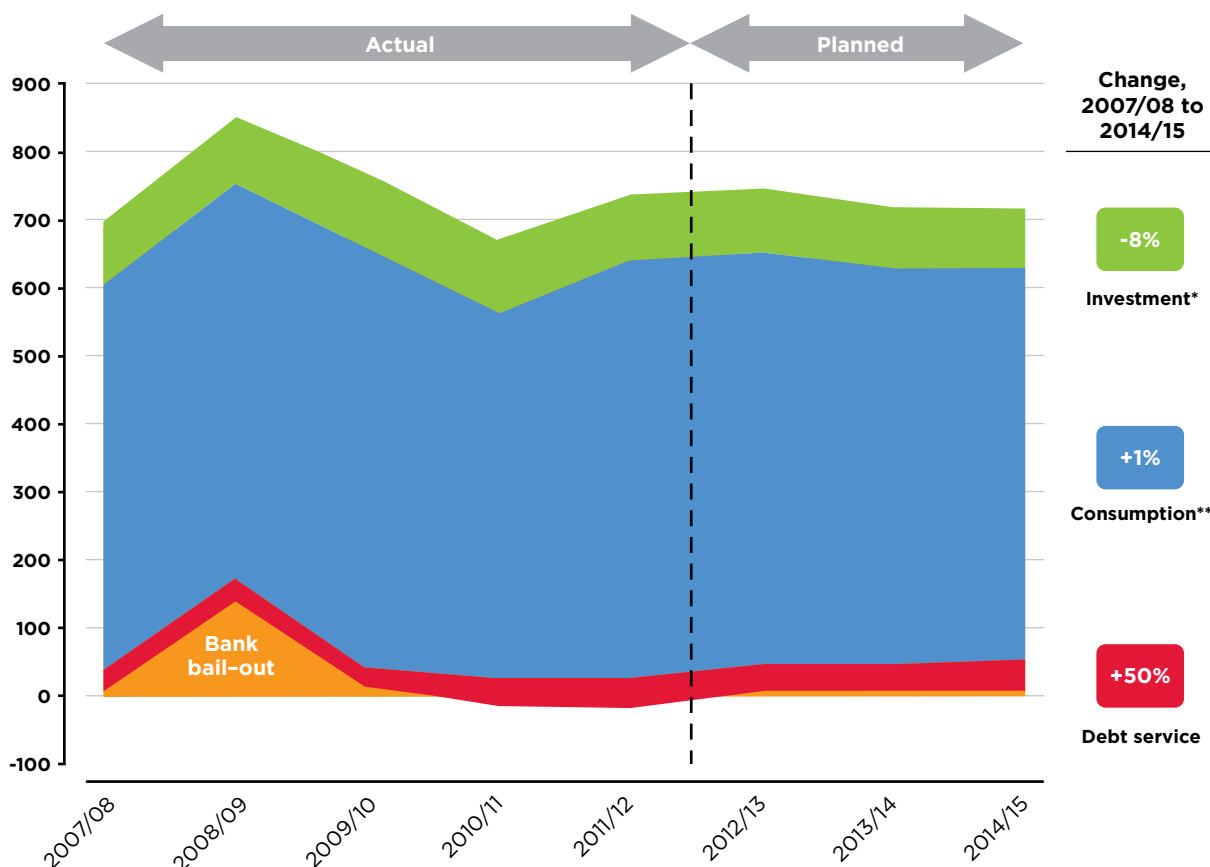
But failing to differentiate between spending that boosts productivity and spending that does not can lead to very wasteful outcomes.⁶⁰ The well known fact that it costs considerably more to send a person to prison than to even the most elite university illustrates the problem. Cutting education or science budgets without increasing efficiency saves money in the short term, but is likely to reduce future prosperity, just as a business that cancels its investment plans is likely to endanger its future growth.⁶¹ This risks creating serious inequalities between the generations, a problem highlighted by the UK's Innovation Minister, David Willetts in his book *The Pinch*.⁶² Today's employees and pensioners benefit from economic growth caused by past investments in education, science, and infrastructure. Just as it is unjust to saddle the next generation with excessive debts, so it is wrong to deprive them of the sources of economic growth by channelling ever more public resources into current consumption rather than productive investment.

This principle also applies to spending on prevention in public services. Because government departments don't look at spending decisions as investments, linking spending today with future savings, it is generally hard to secure funds for preventative spending. This is even more true for innovation in prevention: by one assessment for example less than 1 per cent of all public R&D spending on healthcare goes to behavioural or environmental factors, despite evidence that these explain the majority of mortality.⁶³

Because public spending numbers, and deficit numbers, are treated as aggregates, the public debate is distorted. Spending which could generate future economic growth, or future savings, is treated in exactly the same way as spending which does neither, by both the Treasury and the Office for Budgetary Responsibility, a very different approach from most businesses which distinguish investment from other expenditures.

The distinction is different from that between capital and revenue — some revenue spending, like the running costs of the education system, is an investment in the country's productive capital, while some capital spending, such as the cost of building asylum detention centres, does little to increase productivity. But the important point is that comparing the magnitude of government expenditure on investment in productive capabilities with the amount spent on consumption shows not only that most government spending goes on consumption, but also that the proportion invested in the future has shrunk in the past five years. Meanwhile most of the debate about deficit reduction has been about its scale and speed, not about its composition.

Figure 13: Government ‘investment’ versus government ‘consumption’
– an estimate, £billion, real



*Includes Education, Science, Transport and Capex, linked to economic growth

**Includes operating cuts of most public services, transfer payments, accounting adjustments, and other Capex

Source: Public Expenditure Statistical Analysis, 2012

2. Making our innovation system work better

The second factor that holds back the UK’s ability to innovate is the structure of our innovation system — the organisations, links and norms that determine how new ideas become reality.

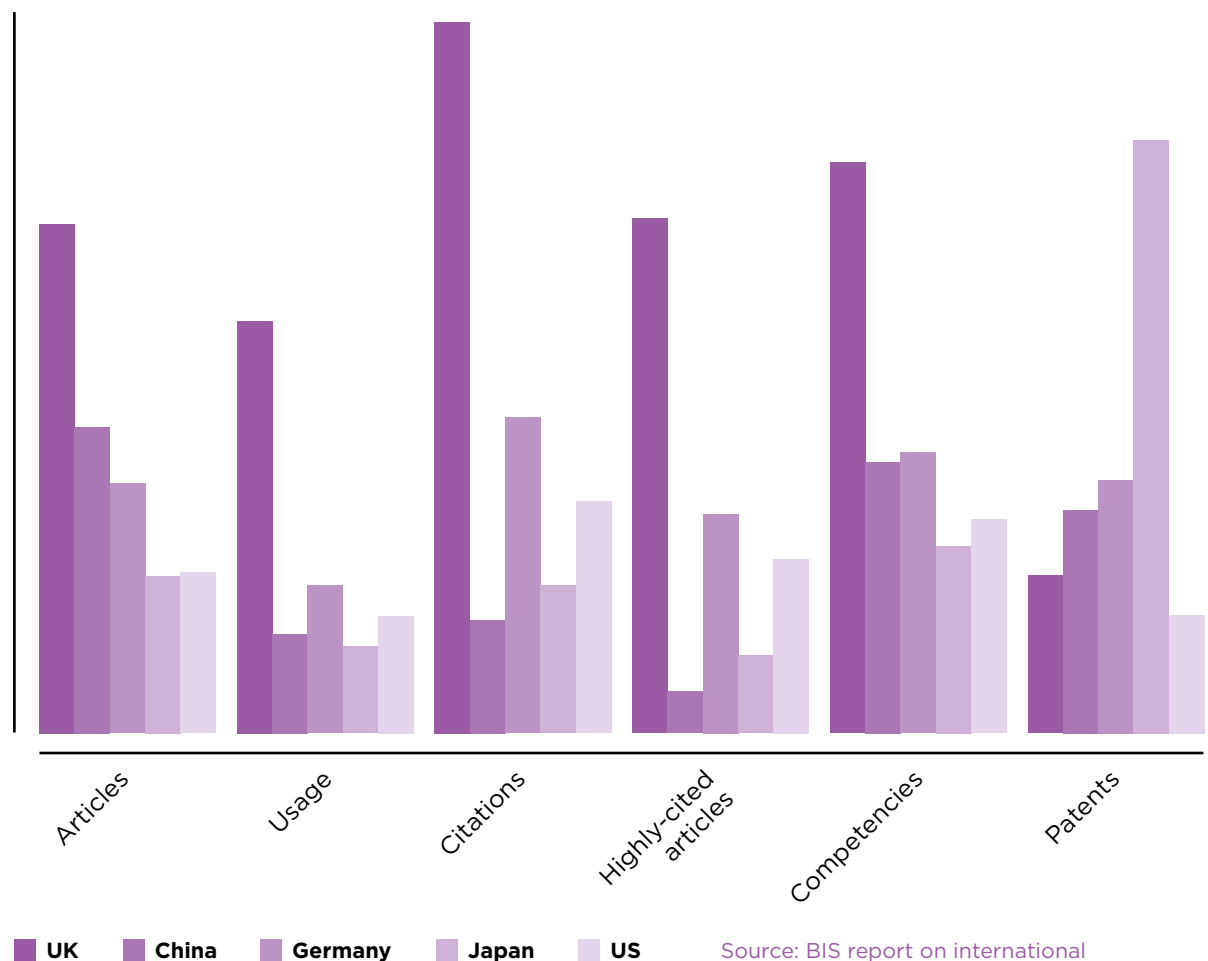
For over a hundred years, commentators have noticed a contrast in the UK between the world of ideas and the world of implementation.⁶⁴ We have excellent higher education institutions (including not just world-class universities but also great art and design schools), and the world’s most productive research base as measured by the number of citations achieved per pound spent (see Figure 14).⁶⁵ But this does not result in world-class performance in the typical metrics of technology, such as patents per head or high-tech manufacturing output.⁶⁶ The long-standing complaint that investment is too focused on upstream rather than downstream activities remains relevant, and almost certainly reduces the economic and social benefits associated with this spending.

In the past 20 years, considerable efforts have been made to improve the UK’s performance in implementing ideas, for example by increasing the incentives on

researchers to have ‘impact’ (e.g. through the Research Excellence Framework). This has had its drawbacks, however. It incentivises a narrow range of behaviours: spin-outs, formal IP licensing and single-disciplinary papers. Research on business–university interactions by Alan Hughes and Michael Kitson of Cambridge University shows that these are not the activities that businesses value most. Instead, businesses look to universities to provide a ‘public sphere’ in which they can develop their ideas, and to act as a source of skilled recruits and informal advice that will generally not take the form of IP.⁶⁷ By privileging IP and spin-outs, our system of research and impact funding discourages these less formal links. What is more, the work of SPRU’s Paul Nightingale, Loet Leydesdorff and Ismael Rafols suggests that the same funding rules discourage interdisciplinary research,⁶⁸ which in the past has been an important source of breakthrough innovations.

Beyond its university system, the UK depends on a wide range of organisations to help businesses develop technological innovations, from standards bodies and measurement bureaus to national laboratories and the Technology Strategy Board.⁶⁹ Some of these, such as the British Standards Institute and National Physical Laboratory, have global reputations and generate significant outside income. In recent years, the government has recognised that these organisations could be better joined up, in order to provide more seamless advice to British businesses and inventors; this is still very much a work in progress.

Figure 14: Outputs per dollar of research spending



Moreover, as Ian Hargreaves observed in his review of intellectual property, the underlying rules of our innovation system, in particular those relating to intellectual property, do not reflect the demands of modern technology.⁷⁰ As the American jurist Richard Posner recently pointed out, patent law works well in industries like pharmaceuticals (where product development cycles can be ten or more years long and new products are discrete), but much less well for products like software, where innovation happens rapidly, or for relatively small and contestable innovations like design features of mobile phones.⁷¹ The growth of patentable ideas leads to the troubling phenomena of ‘patent trolling’ (shell companies buying up portfolios of patents in order to sue innovative companies that accidentally infringe them) and ‘patent thickets’ (masses of interconnected patents held by competing companies that makes it hard for any of them to invest with confidence in a new technology for fear of infringing someone else’s patent). Together these various factors help explain why the uptake of innovative ways of backing innovation (prizes, accelerators, or even well evaluated grant programmes) remains slow.

The unevenness of support for innovation is also striking. While some sectors have benefited from many decades of generous direct and indirect funding (including in particular aerospace and pharmaceuticals, and to a lesser extent broadcasting and media) others have had little support. Services have generally been excluded from R&D support, despite accounting for a majority of economic activity. Less glamorous industries such as agriculture have had little support, despite their role in pioneering modern R&D at centres like Rothamsted.

If public support for business innovation has been uneven and explained more by the power of key interests than by assessments of likely returns, public investment in innovation in public services — with deliberate experimentation on the one hand, and selection of effective innovations to be taken to scale on the other — has been largely non-existent. In the past too much faith was invested either in top-down policy solutions, or in competitive markets — ignoring the key lessons from fields where innovation is more established. Top down policies would nearly always have benefited from more small-scale experiments, improvement and evaluation before they are scaled up. Competitive markets in public services can help the spread of incremental innovations, but as in all other fields of business are ill-suited to more fundamental innovation for all the reasons already discussed. Few of the methods used in innovative fields are common in public services — despite the strong grounds for wanting to drive up productivity. There is still poor use of evidence, few opportunities to redirect resources into more effective new models of service (e.g. shifting funds from treatment to prevention). Well evidenced programmes like Nurse-Family Partnerships, which provide intense support to at-risk mothers, are rolled out surprisingly slowly. In education, only a tiny fraction of the approaches favoured by successive governments have been subjected to rigorous experiment and evaluation. The same is true in health: although there is rigorous evaluation of clinical treatments, successive governments have implemented national policies without any testing, or any serious evidence to show that they will work. According to a survey by the Government Social Research Service, UK government departments may have run as few as 25 randomised controlled trials of the effectiveness of new policies ever.⁷²

As a result, inefficient systems survive largely unreformed, including prisons with 70 per cent recidivism rates, hospitals with equally high levels of readmission and welfare programmes that fail to help the unemployed into jobs.

Finally, as discussed earlier, innovation systems are extremely uneven across the country. In a few parts of the country, in particular parts of the greater south-east and Scotland

but also beyond, dynamic businesses and innovative researchers come together in world-renowned clusters. But in large parts of the country, this is not the case, leaving the economy overly dependent on public services and with little scope to develop the ideas, products and businesses of the future. The lesson of history is that where strong institutions and innovative milieux take shape — from the nineteenth century shipyards of Glasgow to 1990s Silicon Valley, and from the industrial hinterland of Seoul to contemporary Bavaria — a larger proportion of the population become effective innovators. There's a parallel with sporting prowess, which depends on the combination of innate talent and systems. Innovative capability, too, is a muscle that needs to be trained, guided and rewarded. In many parts of the UK, however, weak systems mean that a great deal of latent talent is going to waste.

3. Creating a better culture for innovation

Some aspects of the UK's culture are well-suited to innovation. We have a long tradition of entrepreneurship and a proud history of creative, engineering and design excellence, from Brunel to Jonathan Ive, the propulsion engineers of Derby and the games designers of Dundee. The UK is also the original open society, with a diverse and outward-looking population and vibrant cities. However, there are a number of areas where we are missing out.

The first is how well our education system prepares us for a world of technological change. Elite education includes less exposure to science, technology, engineering and maths (STEM) subjects than many other countries, and despite the UK's engineering and design traditions, our education system has been accused of leading to a prioritisation of cerebral over practical skills.⁷³ There are pockets of excellence, but not enough strength in depth, or what the economist Brian Arthur calls the 'deep craft' that is so vital for sustained innovation.⁷⁴

The UK has particular challenges, but some are also part of a broader European problem, with neither girls nor boys wanting to become scientists, and very little enthusiasm on the part of girls to become technologists (and only slightly more enthusiasm on the part of boys).

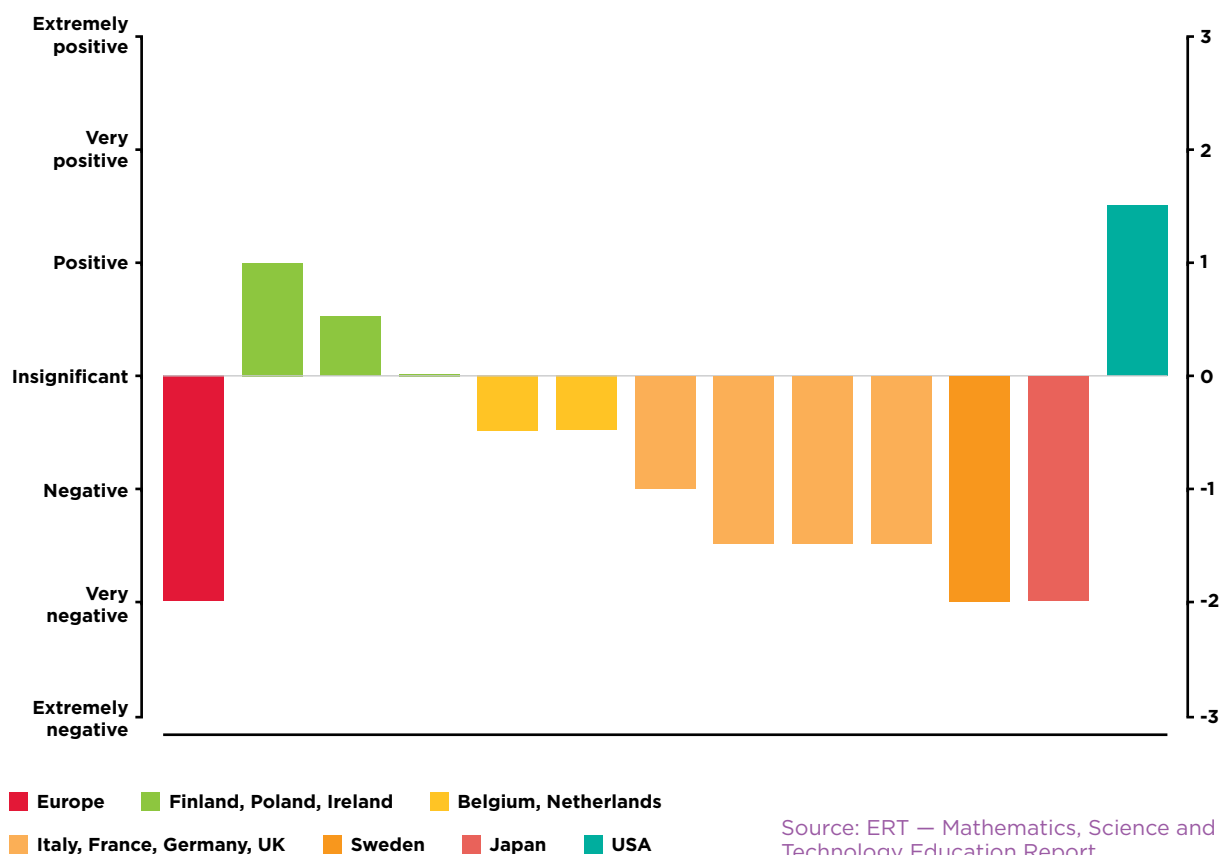
We also know that levels of technical skills play a decisive role in how well innovations are adopted and adapted. Levels of technical skills remain lower in the UK than in other rich countries, despite a century of commissions, reports and initiatives which promised to put this right. New types of school — such as Studio Schools and University Technical Colleges — will play some part in improving technical skills. But other educational reforms may be further entrenching the divide between elite academic institutions, and those concerned with the practical skills that may be more essential to innovation.

The cosmopolitanism of the UK, and especially London, augurs well for innovation. The most innovative places in the world tend to be diverse and open. But there is room for improvement here too. Recent attempts to curb immigration threaten the UK's position as an economy open to the world's best talent, preventing start-ups and universities in particular from recruiting highly skilled people. And the UK is far from being the partner of choice for the rapidly developing economies of China, India and Brazil, which are likely to become innovation powerhouses in the twenty-first century.

The second area of concern is openness, and in particular the barriers against new influences and new entrants. Despite the UK's long history of tolerance, diversity, and entrepreneurship, recent attempts to limit immigration are preventing some of the world's most talented people working in the UK and turfing out new graduates with much to offer British businesses. Despite active competition policy, several important parts of the UK's economy remain dominated by oligopolies — not least the banking sector. The mantra of removing barriers to entrepreneurship is as relevant now as it was in the 1970s or 1980s.⁷⁵

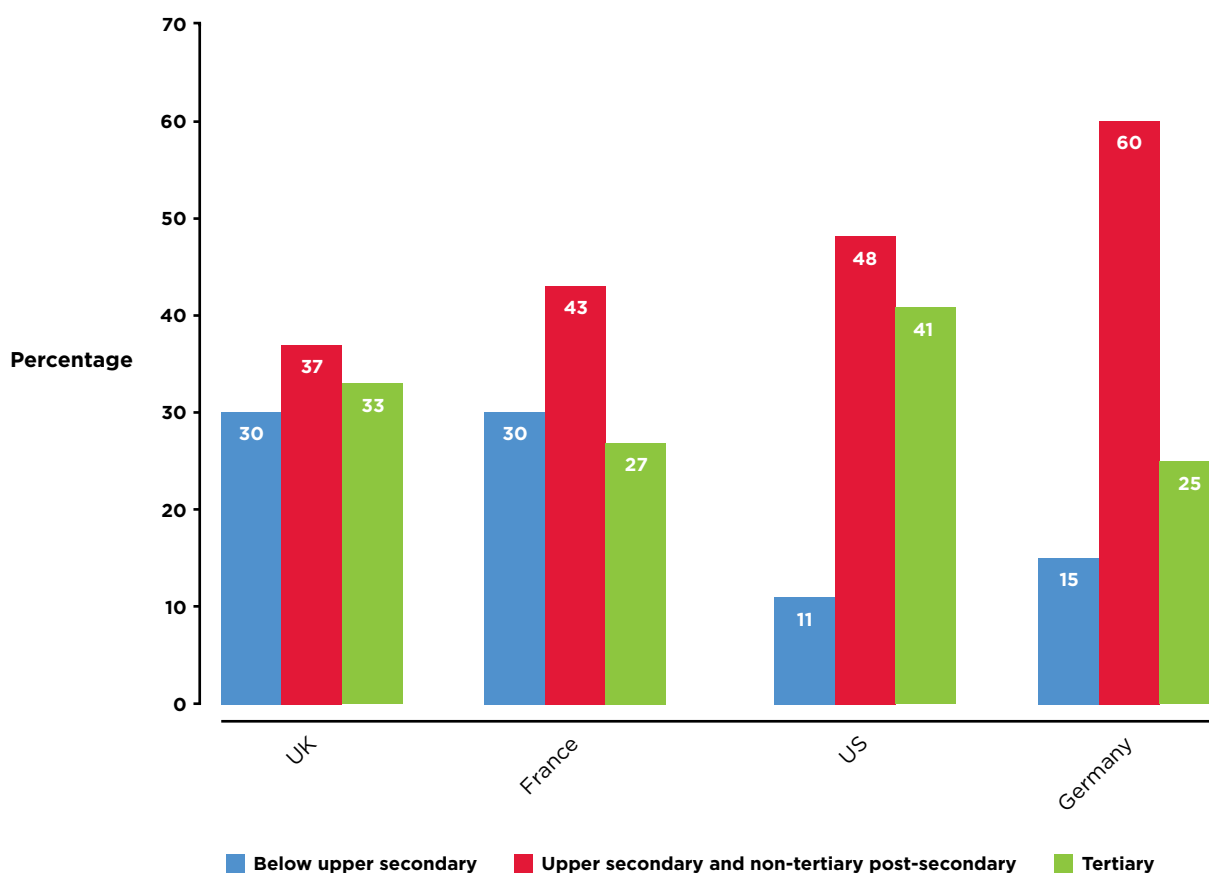
Figure 15: Trends in STEM Education

Indicating trends in the supply of human resources in Maths, Science and Technology (combined indicator from national case studies)



Finally, there is the question of ambition. The UK's pluralism is one of its strengths. But it has also been the cause of much soul-searching about the future of the UK's economy, and has given rise to the angst-ridden question, "how will the UK make its way in the world?" Countries like Finland, Korea and Israel have been better at focusing the energies of their businesses and researchers with grand challenges and a shared sense of national mission, what Peter Thiel has called 'focused optimism',⁷⁶ or what James Woudhuysen has termed 'coherence'.⁷⁷ The role that the 2012 Olympics played in bringing the nation together in a common cause provided a fascinating insight into the shared ambition that the UK generally lacks.

Culture is not easy to change — but understanding the UK's strengths and weaknesses is an essential starting point for nurturing a more innovative society.

Figure 16: Educational level of 25–64 year olds, 2008

Policy: getting out of a PICL

These weaknesses are compounded by confusion over what to do about innovation policy.⁷⁸ Microeconomic policy in the UK has been dominated for the past 30 years by a narrow set of concerns that reflect the dominance of decision-makers and commentators who are much more comfortable with economic theories and policies than they are with questions of technology, engineering or design.

The four most prominent concerns can be described as ‘PICL’ – **P**lanning reform, **I**mmigration liberalisation, **C**ompetition, and **L**abour market reform. In recent publications on how to encourage economic growth, these recommendations are regularly set out.⁷⁹ The argument goes that making it easier to build new houses and offices, bring in skilled staff, enter new markets and hire and fire staff will solve the growth problem. This is not bad advice as far as it goes. On the plus side, the contributions of these concerns to economic growth are relatively well evidenced:⁸⁰ interminable planning processes,⁸¹ caps on skilled migration, entrenched monopolies and sclerotic labour markets can all be convincingly shown to be bad for innovation and growth. That’s why we argue later on for taking each of these significantly further, with more active competition policies to open up finance as well as the innovation process itself; more innovative approaches to labour market reform; planning reforms in high-growth areas; and a more targeted immigration policy.

However, these four prescriptions do not offer a complete and satisfactory policy prescription for a more innovative economy. Indeed, it has been argued that greater labour market deregulation and in some cases tougher competition law could run into diminishing or even negative returns.⁸²

They are necessary but not sufficient conditions for innovation. On their own they don't address the practical questions of how to multiply the creation of ideas, how to ensure that more are developed and taken to scale. The continued prominence of these issues reflects the fact that they are easier to analyse through traditional economic tools. Here we come to one of the fundamental challenges of this plan. Many decision-makers and commentators are familiar with the main precepts of macro and microeconomics. Yet economics continues to struggle to understand innovation, even though it has advanced beyond the 'black box' approaches of a few decades ago. There are now sophisticated analyses of intellectual property, of firm-level behaviours and the dynamics of clusters. But the uncomfortable truth is that when it comes to innovation, economics has relatively few rigorous concepts, few widely accepted causal relationships, no universally accepted measures of innovation, and consequently a weaker evidence base than in many other areas of public policy. No wonder some of the world's best economists believe that the more rigorous understanding of knowledge, innovation and intangibles is now one of the greatest challenges for economics as a discipline.

In the shorter term, however, the problem for advocates of innovation is that economic commentary, which can be very precise when discussing monetary policy or labour market reforms, defaults to vague platitudes when it comes to innovation, or to dogmatic assertions about the role of government. The next section therefore addresses what governments can (and cannot) do to grow innovative capacity.

3. WHAT CAN THE GOVERNMENT DO ABOUT INNOVATION?

If the UK needs more innovation, what can the government do about it? Should it just cut red tape and bureaucratic barriers that get in innovators' way? Should it provide tax credits and subsidies? Should it target a rising share of GDP to be devoted to research (as China and India have done)? Or should it concentrate on creating great institutions to champion new ideas?

Industrial policy versus “Just get out of the way”

The question of government's role in relation to innovation elicits more heat than any other. On the one hand, some confidently assert that government can drive, orchestrate and plan innovation, spotting the key technologies of the future and investing heavily to make the most of them. Others assert with equal confidence that anything government does is bound to fail — and that if only government got out of the way innovation would flourish.

The truth is that both positions are untenable. All the world's successful innovation systems are hybrids, often combining almost opposite approaches: heavy state subsidy combined with lively start-up cultures and venture capital; strong science bases alongside strong industry involvement in shaping R&D. Indeed the successful models reflect the contradictory nature of innovation itself, which has to combine open, creative and speculative discovery alongside focused and disciplined implementation.

Britain's history confirms the need for a more nuanced approach. Many past attempts to create innovative powerhouses failed. The national champions, targeted subsidies, and institutional reforms (like the creation of the Ministry of Technology) are rightly seen as failures.⁸³ The 1965 UK National Plan contains pages and pages of detailed analysis of the UK's industries and their prospects, but did not lead to a golden age of economic growth.⁸⁴ Few governments have had a good track record of forecasting which particular technologies or firms will succeed.⁸⁵ Nor did privatisation and deregulation transform state-owned businesses into great innovators — they left behind stronger balance sheets, but none of the companies that resulted became world innovation leaders in their fields, and usually R&D budgets were cut.⁸⁶

But other policies were more successful. Britain has a strong pharmaceutical industry for many reasons, including world class universities and an integrated NHS. But a critical role was also played by the combination of substantial public funding for basic research and a pharmaceutical price regulation scheme which for over 40 years has had the explicit goal of promoting ‘a strong and profitable pharmaceutical industry’. We have had strong aerospace and defence industries for similar reasons — a mix of generous funding for basic technologies, some strong firms, and stable public procurement.⁸⁷ The UK's strength in fields like advertising and film is in part the result of a very strong public organisation — the BBC — which championed not only skills but also new technologies.⁸⁸

EXAMPLES OF SUCCESSFUL INNOVATION POLICY

There are many ways of supporting specific markets with state interventions without calling it industrial policy. Here are a few examples of public money supporting business innovation and technology development through policy, in a way that encourages exploration as well as commercialisation.

Rolls-Royce and EPSRC

Rolls-Royce is a famous example of a government rescue package, but in more recent years, it has co-funded large amounts of engineering research alongside the EPSRC. Their network of University Technology Centres provides stable funding partnerships with specific institutions, focused on research areas of interest to the company. Beyond this, they have participated in research collaborations such as the ADAM (ADvanced Aeroengine Materials) project,⁸⁹ a five-year collaboration between Rolls-Royce, QinetiQ and six universities, with funding from EPSRC and DTI. This investigation into the behaviour of high-temperature materials contributed to major engine improvements that Rolls-Royce has put into production.

BBC Computer Literacy Project and Acorn Computers

The Computer Literacy Project (CLP) had the grand ambition to change the culture of computing in Britain's homes. Arising from research showing that there was a strong argument for educating the public in the use of computers, the project received significant high-level support from the BBC, through its television broadcasts, and the provision of hardware — the BBC Micro, designed by UK company Acorn — and software.

The CLP was undoubtedly a success for the BBC; millions of viewers watched the TV programmes, hundreds of thousands of users bought the machine and it was a fully integrated response across BBC Enterprises, Education and Engineering. The project also assisted Acorn to go on and have a significant impact on computer science in the UK both directly through high-tech companies such as ARM, and indirectly via the serial entrepreneurs such as Stan Boland, and the companies formed by former Acorn employees, including Element 14 and Icera.

Dundee's biotechnology cluster

Sir Philip Cohen runs one of the most successful research collaborations in the UK, the Division of Signal Transduction Therapy, supported by the MRC and the University of Dundee,⁹⁰ as well as pulling in £2.7million per year in funding from five of the world's largest pharmaceutical companies: AstraZeneca, BoehringerIngelheim, GlaxoSmithKline, Merck-Serono and Pfizer. The MRC provides approximately £4 million per year to support the Protein Phosphorylation Unit, which comprises eight of the 13 research groups in the Division.

The companies share the right to exploit the technical know-how, kinase profiling service and unpublished results, but they pay for special services and to license the Unit's IP. Forty per cent of the funding for this collaboration goes to a service facility with 25 staff in a series of 'backup' teams that support the 14 research groups. This expert team can be accessed by the companies, providing reagents and chemicals which generate a further £4 million per company over the four-year period. The unit has successfully spawned a number of start-up companies, most of which remain in Dundee.

Even apparent failures can have longer-term benefits. The government's promotion of Inmos as a national champion in the semiconductor industry in the 1970s was a failure in its own terms: Inmos did not thrive and ended up as a subsidiary of ST Micro. But it paved the way for a thriving microelectronics cluster in the south west (said to be the world's largest cluster of chip designers outside the US), driven in part by entrepreneurs who started their careers at Inmos.⁹¹

The experience of other countries in recent decades also undermines simplistic faith either in states or markets. If we look around the world at which nations are succeeding many different models are in play, often involving levels of state support that would be considered excessive in the UK. Taiwan achieved dominance in microprocessor manufacturing, a technology-intensive sector of which it controls 80 per cent of the global market, thanks to very concerted government strategy over several decades.⁹² Finland has become a rich country with a strong manufacturing sector, through a combination of generous public funding of both basic research and downstream development, effective state agencies (such as Sitra, TEKES⁹³ and Finnish Industry Investment) and one large firm, Nokia, that has built a diverse ecosystem of small businesses around itself. Israel has a dynamic defence and IT industry thanks to a mix of public venture funds that were then privatised,⁹⁴ an immigration policy that brought in tens of thousands of highly skilled Russians, an engineering culture nurtured in part through military service⁹⁵ and the highest expenditure on R&D (as a percentage of GDP) in the world.⁹⁶ Germany remains a powerhouse in advanced manufacturing thanks to a deep-rooted network of agencies, strong relationships between firms, world-renowned technical skills, which have proved very hard for other countries to emulate,⁹⁷ and a strong science base.⁹⁸ And the United States, that proverbially free-market country, built many of its most successful innovations off the back of its government's lavish investment in science and technology, mission-related health and defence funding, state-backed investment programmes and pro-business procurement policies.⁹⁹

This kind of country-to-country comparison can be criticised for being anecdotal. But it is complemented by a growing body of empirical economic research that suggests that some industrial policies can work well. For example, a team led by the LSE's John Van Reenen used clever natural experiments to show that some grants to small firms in the UK were effective in increasing productivity,¹⁰⁰ while Harvard's Philippe Aghion and colleagues used a detailed study of Chinese industry to show that sectoral subsidies were effective in increasing productivity, especially in competitive sectors.¹⁰¹

In every case of national innovation success around the world we find governments supporting the many things which markets are not well designed to do:

- Not just basic research, but also applied research and translation where technological uncertainty is high
- Supporting the growth of clusters (although few governments have had any success in creating them out of nothing)
- Stimulating the flow of ideas from universities into the economy and society (albeit much less through IP as was assumed in the 1980s and 1990s than through people)
- Setting challenges in the form of targets and prizes
- Using public procurement to be a lead customer for new innovations
- Easing access to new finance for innovative businesses, for example by helping venture capital funds get off the ground or easing the supply of growth capital
- Supporting adoption, through skills strategies, tax credits etc.
- Opening up competition and breaking down monopolies

Many of these themes are not new. Nearly all were there at the birth of Silicon Valley, arguably the most generously funded and most successful example of a public strategy to support innovation. Many echo the prescriptions proposed more than a century ago by Friedrich List, who played such a decisive role in Germany's industrial prowess, or Alexander Hamilton, who set the policies that helped build America's industrial base. Yet each successful country has followed its own distinct trajectory, tailoring similar elements to very different conditions.

Governments are very capable of backing the wrong technologies or wasting money — and British governments have done all these things. But it's as untenable to claim that if government got out of the way innovation would flourish as it is to claim that governments can innovate on their own. Instead the lesson of history is that it's the nature of the relationship between governments and entrepreneurs, innovators and businesses that matters — and that the detail is all important.

How not to make innovation policy

So what should government do now? How should it understand its role? And what tools should it use?

Clearly it matters to get the basic conditions right. Innovation is an investment, and it flourishes in conditions where people are willing to invest. The rule of law, stability, good tax policy, competition law and easy access to talent all make it more likely that businesses will take a chance on something new. But as we have seen, the world's most innovative economies have done much more than this. What works for the UK as a largish nation is bound to be different from what works for nations a tenth the size (like Finland or Singapore), or for a superpower like the USA. We neither can nor should be as specialised

as some smaller nations; but nor can we afford the very large prestige initiatives of a superpower. Cut-and-paste will not work.¹⁰² Nor will innovation policy by metaphor: leaning on phrases such as national champions, entrepreneurial heroes, ‘gazelle’ businesses, pipelines and flows of knowledge, or the language of ‘innovation ecosystems’ that has been popular since the 1980s. These all help to fill out political speeches, but they obscure more than they clarify.¹⁰³

Designing an innovation policy

Rather than cutting-and-pasting another country’s innovation policy, or basing policy on inaccurate metaphors, we should take a leaf from the book of industrial designers. At its heart, design involves arranging fundamental elements according to a few overarching rules or ‘design principles’, and then furiously adapting and improving them in the light of experience. This section sets out four design principles for effective innovation policy.

1. **Experimentation.** Innovation is a risky business. Breakthroughs only come from a willingness to push at boundaries, to take risks, and, sometimes, to fail. If the government is to play a role in innovating, it’s essential that it does so in the expectation that much of what it does may well fail, and that when things are not working they will be stopped.¹⁰⁴ The inherent riskiness of innovation is one reason why so much of it has to be done at arm’s length from politics through independent agencies, like research councils or separate agencies like DARPA. What matters is not backing winning projects every time, but backing a good portfolio of projects, and having the honesty to acknowledge when things go wrong and stop funding them. Knowing what is working requires being conscientious about data and evaluation: more randomised controlled trials of innovation policy would help, as would more thorough gathering of data. Having a diversity of initiatives also helps: the US system is notable for the wide range of organisations responsible for promoting innovation: DARPA, the National Institutes of Health, the Office of Naval Research, NASA and many other bodies have all pursued their own path, while the SBIR programme is run through a large number of departments rather than centrally.

This stands in sharp contrast to the traditional model of policy development in the UK (and many other countries), in which a new idea is centrally devised, announced to great fanfare, rolled out nationally and defended to the hilt by the government whether it is working or not — and if it is not, being very gradually allowed to fade away rather than briskly terminated.

Experimentation is not easy, especially in an adversarial political system: in Westminster, as in the Vatican, it pays to seem infallible. It is likely to require significant cultural change in how government thinks about its role in relation to the economy. But applying this principle is perhaps the most important role of political leadership in innovation policy.¹⁰⁵ Franklin D. Roosevelt is almost unique amongst political leaders in having made a virtue of experimentation, and the failure that comes with it. He thought it was obvious that leaders had to take risks — particularly when faced with huge challenges like mass unemployment, and it should be equally obvious that risks need to be taken in the face of huge challenges like ageing or climate change, as well as in making the most of great new opportunities like the Internet of Things or synthetic biology.

- 2. Entrepreneurship.** Entrepreneurs are essential to an innovative economy: they don't usually come up with ideas, but they do work out how to put ideas into practice. Entrepreneurship is also important to good innovation policymaking. The flip-side of an experimental innovation policy is the need for entrepreneurial leadership and challenge within the system. Some of the most successful examples of innovation policy in Taiwan, Korea and Finland relied on leaders with a strong vision to shape policy, from the role of Chao Chen Wang in developing Taiwan's semiconductor industry to the leadership shown by Esko Aho in crafting Finland's innovation-based response to the deep recession of the early 1990s. The UK has had its equivalents: the role of Lord Young and Lord Heseltine in shaping growth policies in the 1980s or the role of Lord Drayson in the 2000s in promoting life sciences and low emission vehicles shows that entrepreneurial leadership within the system can be valuable.

These kinds of figures provide a valuable antidote to consensual policy that works primarily with incumbents. This is not a matter of bringing in heroic figures from outside and shoehorning them into government jobs, but of making government more open to outsiders, and as a result encouraging new styles of working.

To encourage entrepreneurship in innovation policy, government should:

- Set a clear overarching framework within which new initiatives will run and be evaluated (and stopped if they are ineffective), agreed at a cross-party level.
- Recruit dynamic individuals, and give them budgets to create programmes and teams, rather than classic bureaucratic roles. These may well be time-limited, not permanent, bodies, and evaluation should be baked into their structure. This is closer to the model that DARPA has followed, with considerable success.
- Establish competing funds in important areas of application, for example using challenge prizes alongside a more consensual structure to encourage outsiders to participate, or competing teams and partnerships to address the same big problems (as NASA famously did to design the vehicles for the first moon landing).
- Experiment with innovation champions — appointing specialists charged with both coordinating innovation and removing the barriers blocking promising ideas, whether these lie within the public sector or financial institutions, and reward them according to demonstrable success across a portfolio of projects.

There's also a role for entrepreneurship in cities and regions, to forge the most effective connections between businesses, researchers, finance and incubation. Innovation policy neither can nor should be run solely from Whitehall. More distinctive strategies driven from Edinburgh, Cardiff and Belfast, as well as cities like Manchester or Newcastle, should encourage a more sophisticated public debate about innovation strategies, improving the connections between universities, big firms, entrepreneurs, and some healthy internal competition.

We also need diversity in the policymaking process, appropriate for very different industries and places. For some sectors, such as life sciences, the allocation of basic research funding will be crucial. For others, such as engineering-based industries, co-funding to develop concepts is more important, in particular through

government procurement. In still others, government's most useful role is to create the right conditions — removing barriers to immigration of skilled staff, or removing the obstacles to infrastructure being built. This means that governments need not develop a single monolithic innovation strategy, but dedicated teams working in different areas.

3. **Openness.** Good innovation policy cannot be made by government alone. And it cannot be delivered solely through state bodies. Innovation flourishes when businesses, research organisations, and intermediaries such as standards bodies and trade bodies come together to identify and address major challenges. (Consider for example the role of Stanford as an intermediary in Silicon Valley, or of the IEEE in determining technological standards in the US more generally.) This approach has had some success in the UK in the Office for Life Sciences assembled under the previous government, and in the way the present Government has worked with the east London internet cluster¹⁰⁶ and the agrifoods sector.¹⁰⁷ However, government cannot rely simply on assembling interested groups – this risks capture by incumbents and vested interests. Challenge prizes and crowdsourcing provide ways of ensuring new firms and businesses in entirely unrelated sectors are not shut out. The UK has a long history of using openness: during WW1 for example, the Navy used what would now be called crowd-sourcing to gather over 40,000 ideas from the public.
4. **Ambition.** Finally, innovation policy needs ambition, with the right mix of challenge and focus. Government's power as a leader, as a customer and as a regulator matters as much as its narrow role as a supporter of research and development. Finland, Korea and Israel are all countries that have managed to make this a reality. In all cases, leadership has come from the top but been broadly based.

To achieve the equivalent effect in the UK, which is a somewhat larger and less politically consensual country, the government must put political capital behind innovation. The Prime Minister should lead an Innovation Council with the sole aim of making the UK a more innovative place. This should include key ministers not just from BIS but from other departments. A senior official should coordinate actions, and have a 'double key' to agree departmental innovation plans and align overall budget planning. The government has a great systemic impact on important industries well beyond BIS — the Department of Health in healthcare and life sciences, Department of Energy and Climate Change in energy, the Ministry of Defence in aerospace and electronics, and the Department of Culture, Media and Sport in the creative sector. This council should also include industry leaders and experts (drawing on the expertise already embodied in the Council for Science and Technology), and, if possible, should take a leaf out of Finland's book by including opposition leaders to create a cross-party consensus on innovation.

The process of making innovation policy must be future-focused. This means that the personnel employed by government to work the system must be open to future technology developments and social and business trends, and not overinfluenced by currently powerful incumbents. This requires a combination of technical and business expertise (more frequently to be found in the French, German or American governments than in the UK's), and a sensitivity to new ideas — one way of developing this is by foresight exercises, which are not great at predicting the future but better at making those who undertake them recognise the future when it manifests itself.¹⁰⁸

Policy also needs to be aligned. A frequent complaint made by foreign businesses looking to make major R&D investments in the UK is that government policy is poorly aligned: helping to orchestrate such things as land, planning, training, supply chain development, and links to universities.¹⁰⁹ Of course, some resources for innovation need to be open for discovery, speculation and experiment, with as few bureaucratic constraints as possible and as much freedom for innovators to pursue their hunches. But some resources need to be used more strategically, with government working with business and academia to identify important questions and focus efforts towards them. These may be grand challenges like ageing or climate change, which cut across business, public sector and daily life, and they may include making the most of new knowledge — e.g. in high performance computing. The key is to be clear what question is being asked, and where innovation may be able to create the greatest public value. Here our innovation policy lags behind that of Germany and Japan, both of which use grand challenges as a way of organising and focusing innovative activity.

The role of democracy

Good innovation policy isn't a matter of neat organograms populated with national institutions and funds. Instead, it needs a dynamic mix of organisations appropriate for the UK's systems of discovery — resources linked to challenges or to individuals; markets for outcomes calling forth more innovation; places competing to be laboratories for the future on big issues from transport to genomics to obesity.

To make that possible we need a broader and deeper political consensus for innovation. Without this, more popular causes will take priority in voters' minds, and the short term will triumph over the longer term. The UK has influential and very well connected groups in science, business and higher education. But they have concentrated on the inside track, not on public engagement and argument. This stands in contrast to the national importance of innovation in Finland, Korea, Israel or even the US, where there is a broader recognition of the role of innovation and especially science in economic growth and national greatness. If innovation policy is to be taken seriously and funded seriously, it must reconnect with a wider audience: not the handful of senior researchers and business leaders who participate in government roundtables, but the hundreds of thousands of people who work in innovative industries, who hold degrees in sciences, engineering, or creative subjects who are disruptive entrepreneurs and social innovators or who are passionate about technology.

This group is very knowledgeable but not much engaged in the strategic choices described in this plan. Books like Mark Henderson's *The Geek Manifesto* and Ben Goldacre's *Bad Science*, and the wider role of technology in popular culture, are increasingly giving it a voice. A growing proportion of the population has a reasonable understanding of science, as well as design and social creativity. The UK has a long history of engagement with the future — from the Great Exhibition to sci-fi, and pioneers like Brunel and Berners-Lee. Yet it tends to be taken for granted. It's disconnected from national debate, as has been very evident through the endless public debates over responses to the economic crisis.

That needs to change if we are to put in place a sustainable alternative to stagnation. We need business leaders who are willing to prioritise the case for innovation over other issues such as top rates of tax or regulation. We need to use critical moments of choice — such

as the imminent 4G spectrum auction – to sharpen thinking about priorities. And we need political leaders with a deeper understanding of innovation (at present only a tiny fraction have direct experience), and an appetite to advocate it.

The general principle of innovation policy is that because we all stand to benefit from innovation, we should collectively mitigate the costs and risks of innovation, which would otherwise fall heavily on the innovators themselves. That's a highly political principle. And it needs political and public advocacy and argument if it's to be widely supported.

4. POLICY PROPOSALS

This report has so far looked at the case for innovation as an answer to the UK's economic problems, examined the state of innovation in the UK today, and considered what the appropriate role of government in encouraging innovation. The final section looks at the three areas where we believe most needs to be done to improve the UK's climate for innovation: increasing investment in innovation; improving how our innovation system works; and making our culture more conducive to innovation.

Underlying this whole plan is a simple premise: that the UK's potential for effective innovation is substantially underused. The idea that only a tiny handful of people have the talent to create is widely believed in the upper echelons of British society. But it has been disproven again and again by our own history, as innovative strength in depth was achieved in fields as varied as engineering, computing and music. And it has been disproven elsewhere as a succession of countries have made the transition to become world class innovators. Their populations didn't change; but they did become much better at making the most of their talent. The right environment, the right institutions and the right rewards, can give far more people the confidence to develop their ideas; the determination to develop them; and the resources to put them into effect. Where that happens, and a nation or city acquires the 'deep craft' of innovation in a particular field, whether it's aerospace or computer games, healthcare or energy, the economic rewards are great.

A look at some of the world's most innovative countries and regions, from Silicon Valley to Finland and from Israel to Korea, shows some notable similarities.

- **Investment.** They invest adequately in innovation. Although financial systems differ, successful innovative countries provide a financial architecture that can fund ideas to grow to scale and contribute intelligence as well as money. Whether the model relies on VCs, like Israel or the US, hands-on banks, like Germany, or state co-investment, like Singapore or Korea, it must see innovation through for the long term. Public spending in these countries too values investment in innovation, not just consumption: even the free-market US has a long track record of backing science and technology through organisations like the NIH and DARPA.
 - **Systems.** They have well connected, vibrant innovation systems, with effective interactions between researchers, large businesses, entrepreneurs and the wider world, backed up by good institutions and sensible government policy. From the dynamic connections between the engineers, investors and entrepreneurs of Silicon Valley to the tight links between Korea's government, universities and large tech firms, the right systems matter.
 - **People and culture.** Finally, in their different ways, they have a culture of innovation. From the cosmopolitan entrepreneurialism of Silicon Valley, where engineers and developers flock from around the world, to the less diverse but equally globally minded cultures of Finland or Korea, openness matters, as does a commitment to, and understanding of, new technologies and new ways of doing business.
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Below we propose 12 sets of policy proposals that address these three aspects of what makes an innovative society. Some of them are politically controversial, such as change to our financial system and how it supports innovators; others will require significant shifts in resources and how we run major institutions. But they are the kinds of measures that the UK needs if it is to become a better place to innovate in the decade to come and beyond.

Plan I could be implemented without any additional costs to taxpayers, or any increase in the deficit. The proposals would be funded by redirecting currently committed spending, and by using the windfall from the forthcoming 4G spectrum auction.

INVESTING IN INNOVATION

Innovation is in a fundamental sense an investment. Developing new products or doing things in new ways takes time and money, and in the short term is rarely as lucrative as business-as-usual. This means that one of the preconditions for innovation is a favourable investment climate: effective financial markets that are willing to back innovative risk-takers; a government that invests in the future and, where appropriate, acts as a lead customer for innovative businesses; and the provision of infrastructure that encourages innovation. Public policy has an essential role to play here: consider the importance of the American government in channelling billions of public and private funds into innovation through organisations like DARPA and the Small Business Investment Companies programme, Israel's Yozma programme which kick-started its venture capital industry, or the role of Sitra in Finland as a long-term patient investor.

We need to follow these examples and create the right incentives for more investment to go towards innovation, both from private and public sources.

1. Reshaping the UK's financial architecture

The UK plays host to one of the world's most sophisticated financial services sectors. But the vast majority of its activities do not relate to financing innovative businesses, which often report difficulties in accessing finance. The restructuring of the banking sector following the 2008 financial crisis and the Bank of England's ongoing programme of quantitative easing offer opportunities to strengthen the UK's financial architecture and make it more useful for innovative firms – in particular to help firms grow.

Background

"Water, water everywhere, nor any drop to drink." The UK hosts one of the world's most sophisticated financial centres, attracting talent and ingenuity from around the world and employing over a million people. Financial services seem to be more than pulling their weight in Britain's faltering recovery.¹¹⁰ But at the same time, innovative businesses in the UK report widespread difficulties in obtaining finance, with particular gaps in 'follow-on' funding, and a lack of public markets on which to sell companies.

It's easy to say that the UK financial sector took too much risk in the last decade, and that innovation is the last thing it needs. This is true on one level. The UK's banks, like those in many other countries, took advantage of lax regulation and global capital imbalances to make disastrous gambles. On the other hand, if we want the economy to recover, risk is exactly what we need: our financial system should be willing to back businesses that take risks and innovate in search of competitive advantage, new markets and growth. But to do that it needs the right financial tools; much better methods for assessing risk; and the right combinations of finance and knowledge to enable subtle judgements about who to back.

Innovative UK businesses face many challenges when it comes to obtaining finance, including:

1. A venture capital sector that provides abundant finance for internet and software businesses, but much less to other high-tech businesses,¹¹¹ whose long-term returns make it difficult to attract outside investment and whose business models are being challenged by new competitors¹¹²
2. A banking sector that is relatively uncompetitive, too homogeneous,¹¹³ and now rapidly deleveraging,¹¹⁴ and which has trouble providing growth businesses with the finance they need to expand,¹¹⁵ coupled with a lack of non-bank finance options (such as bonds or junior market flotation); this has been identified as a significant structural block on economic growth¹¹⁶
3. A perceived culture of short-termism in public markets, which appears to be hostile to investment in innovation¹¹⁷

In most of the world's richest and most innovative nations, this would simply not be acceptable. Countries from the US and Germany to Korea and Finland have ambitious institutional measures in place to ensure the financial sector serves the real economy — especially innovative, risky, growing businesses. The economies of these countries rely on large-scale government interventions: the Small Business Investment Corporations in the US, Germany's Kreditanstalt für Wiederaufbau and High-Tech Gründerfonds, the Korea Tech Finance Corporation and Korea Credit Guarantee Fund, and Finnish Industry Investment and Sitra in Finland. In the US, the Small Business Administration provides several large loan guarantee programmes for banks and (through the Small Business Investment Corporation programme) to private equity funds, all with an explicit business growth agenda.

The effect of these policies, and of the deep-seated structure of the financial system, is that there are several countries where banks are more willing to provide patient capital and to back innovation and risk¹¹⁸ than they are in the UK. At the same time, the UK's markets for non-bank sources of finance (venture capital, angel investors, and growth and mezzanine finance and corporate bonds) are much thinner than they are in the United States. British businesses find themselves in the no-man's-land of corporate finance, adrift between the patient attentions of European bank-based capitalism and the deep pools of risk capital available in the US.

When compared to other countries, the UK government's efforts over the last 20 years have been characterised by two factors: a focus on early-stage finance and the sheer number of often quite small-scale interventions. We have seen a range of efforts to improve access to finance for early-stage businesses, including the establishment of several government-backed VC schemes and tax breaks, and a more intense burst of effort by policymakers since the financial crisis, involving the establishment of the Innovation Investment Fund (IIF), New Enterprise Capital Funds, the Enterprise Guarantee Scheme, the Business Finance Partnership, the Business Angel Co-investment Fund, an increase in the Enterprise Investment Scheme and the launch of the very generous Seed Enterprise Investment Scheme.

Summary of publicly-backed finance for early-stage businesses

Fund type	Total funds available (during investment period)	Investment size range	End of investment period	Geographical scope
Early Growth Funds (EGFs)	£36.5m	Up to £200k	2014–2016	Regional
Enterprise Capital Funds (ECFs)	£185m	£500k–£2m	2011–2013	National
Scottish Co-investment fund	£72m	£100k–£1m	Currently investing	Scotland
Business Angel Co-investment fund	£50m	£100k–£1m	Currently investing	England
Venture Capital Trust (VCT)	£150m pa	Businesses can raise up to £5m via the scheme in a 12 month period	Not applicable	National
Enterprise Investment Scheme (EIS)	£260m pa	Businesses can raise up to £5m via the scheme in a 12 month period	Not applicable	National
Seed Enterprise Investment Scheme (SEIS)	£20m pa	Businesses can raise up to £150k via the scheme	Not applicable	National

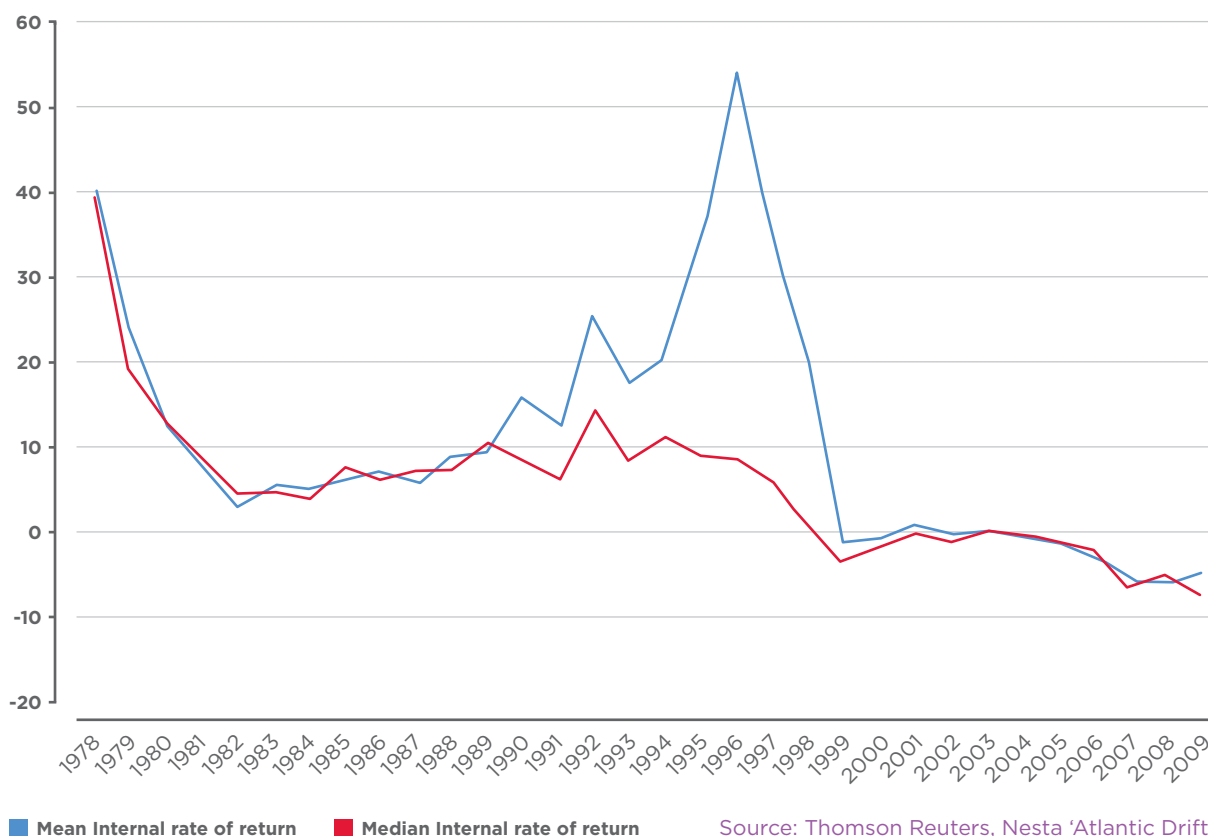
Source: BIS/Nesta

This abundance of policies has had some advantages: the quality of VC intervention improved in the period from 1995 to 2012, partly as a result of learning from past mistakes.¹¹⁹ The Enterprise Capital Funds (ECFs) and Innovation Investment Fund (IIF) are public-private coinvestment funds-of-funds, designed to ensure the resulting funds are sufficiently large to be effective; this follows international best practice documented by Josh Lerner in his survey of global VC policy,¹²⁰ and has brought talented investors into the market, like Haakon Overli's Dawn Capital and Steffen Glaenger and Eileen Burbidge's Passion Capital. Capital for Enterprise Limited (CFEL), the government organisation set up to administer its investments, has brought coherence to the portfolio and established itself as a respected limited partner.

But it is hard not to draw the conclusion that efforts to help innovative businesses by directly promoting the VC industry are running into diminishing returns. Since the dot-com bust, the majority of money invested in UK early-stage VC has come from the public purse.¹²¹ Even prominent members of the British venture capital community have recently suggested that further investments in VC funds will not necessary help the UK tech sector.¹²²

It is not just diminishing returns that VC policy has to worry about. There are growing rumblings on both sides of the Atlantic that the venture model itself is broken as a way of investing in high-growth start-ups. This concern has partly been sparked by poor returns¹²³ (which even for the top-performing funds have never come close to their dot-com era heyday) and partly by a feeling that the industry itself needs to innovate to cut costs, and to generate new models for how it raises money and how it invests it.¹²⁴ Interesting models are multiplying — from Russian tech investor DST's move to fund entire Y-Combinator cohorts to 500 Startups's deployment of Big Data to identify investment opportunities — but it is not yet clear which models will win the day.

Figure 17: Venture capital industry performance by vintage year (US, UK and continental Europe)



Government policy to encourage angel finance may also be cranked up as high as it can go: angels (who as Nesta's research has shown are undoubtedly an important source of finance¹²⁵) recently benefited not only from an increase in the EIS, reform to EMI (Enterprise Management Incentive scheme) and support for angel networks, but also from the establishment of the new and generous SEIS scheme and a £50 million coinvestment fund run by CFEL, and the hands-on efforts of the government's enterprise adviser Lord Young. Before focusing further on angels, it seems wise to give these policies time to take effect.

There are, fortunately, many other promising areas of opportunity for increasing the flow of investment into potentially high-growth innovative firms.

First, it has long been clear that while venture capital can be a good way of financing internet and social media businesses, it is less appropriate for many other types of tech businesses with longer time horizons or greater capital requirements. Biotech, green tech and semiconductors have benefited from some VC investments over the years, but far less than the internet sector. This is in part driven by the economics of VC investing in these sectors: as Josh Lerner has observed, the average annual return from 1991 to 2011 of (US) venture capital funds in software and internet businesses was 19 per cent; in other investments it was a lacklustre 6 per cent.¹²⁶ Given the UK's strengths in semiconductor design, life sciences, several aspects of complex software design, and some types of advanced manufacturing, this seems like an obvious issue to try to address.

Second, innovative UK businesses that succeed still face a problem of accessing growth capital. Banks have typically been resistant to providing this (analysis by Experian and Nesta in 2010 suggested that banks' credit scoring ratings systematically favoured low-growth over high-growth businesses, all other things being equal).¹²⁷ And other sources of growth capital are underdeveloped — the new Business Growth Fund, established by the main clearing banks, is only just beginning to make investments and remains relatively small; AIM listings are far rarer than they were a decade or two ago; and despite the growing reputation of the London Stock Exchange's Order-book for Retail Bonds, corporate bond markets are still mainly the preserve of large or at least medium-to-large firms.

Finally, it is worth engaging with the issue of short-termism among investors in British businesses. This is necessarily a long-term goal; after all, this issue is at least as old as the 1931 Macmillan Committee. But times of crisis are when culture is most likely to change, and now is without doubt a time of protracted crisis for the UK's banking sector — and an opportunity for change.

PROPOSALS

If we are looking to make a significant improvement to the financial architecture for innovative businesses in the UK, three areas need attention. The aftermath of the financial crisis and the Bank of England's ongoing programme of quantitative easing provide a once-in-a-generation opportunity to reshape the UK's financial architecture for the benefits of innovators and entrepreneurs.

Risk capital in early-stage tech businesses

Government support for traditional VC is already generous; to be worthwhile, further investment must meet clear needs that current policies do not address. Finance allowing the earliest-stage ventures to grow remains in short supply (this is particularly the case for investments outside the traditional VC sweet spot of internet businesses). There are widespread signs that the VC industry itself is going through a transformation, and it remains to be seen what investment models will emerge triumphant. Businesses need finance not just to start up, but to scale and grow.

Further public co-investment could meet these three needs if structured carefully. We recommend the investment of a further £200 million into early-stage financing, made available from 4G auction proceeds, as suggested in the next chapter. This money should be targeted at:

- Backing early-stage non-internet tech businesses that have largely missed out on VC funding because of their different lifecycles and capital requirements. A £150 million co-investment over three years, either into funds (using an ECF model) or into individual deals (mimicking the angel co-investment fund) should be used to back deals outside the traditional VC hunting grounds of internet and software start-ups to give businesses the finance they need to grow. Given the track record of VC in these sectors, these investments may very well lose money, but the rationale for public investment is that developing new high-tech sectors brings a benefit to the wider economy.
- Encouraging experimentation by investors to devise new and effective business models for how to invest in early-stage businesses. Several past examples have shown how public co-funding can help de-risk new investment models — Israel's Yozma, a successful initiative to invest public money into VC funds, was an example of just this, kick-starting the then unproven Israeli VC sector. Smaller scale examples in the UK include the funding by Capital for Enterprise of hybrid angel/VC funds like Passion and Dawn, or Nesta's own investment in the Big Society Finance Fund to develop new social investment products. Future government intervention in the VC sector, whether at a national level through CFEL or at a European level through the European Investment Fund could focus on entirely new investment models, with a view to encouraging funds to identify new and better business models that address the global malaise of venture capital as an asset class. Another option that warrants serious experimentation is the creation of Innovation Bonds that bring together pools of IP. Japan's INCJ is attempting something similar on a very large scale, helping to commercialise ideas coming out of their universities. Investing £50 million into this sector would make a significant contribution to the development of innovation in early-stage investment.
- Any new funds set up in this space should look to develop relationships with the Business Growth Fund, which makes growth capital investments in more mature businesses, to help provide growth finance if and when they develop and with the Technology Strategy Board's well regarded SMART awards programme, which provides grants to innovative early-stage technology companies.

More non-bank finance

Banks have long been reluctant to invest in growth businesses, in part because they often have few assets and large working capital requirements. The need on the part of the banks to restore their balance sheets and comply with tightening regulations is likely to make this worse.¹²⁸ Instead, we need to look to non-bank providers to finance growth businesses:

- Encouraging more start-up providers of non-bank finance. New crowdfunding providers offer both equity (e.g. Seedrs) and debt finance (e.g. Funding Circle), or allow people to invest in trade receivables (e.g. Market Invoice). The new Financial Conduct Authority must ensure that its authorisation and regulation process does not stifle these kinds of new initiative. The new £1 billion Business Finance Partnership, set up by HM Treasury to coinvest in innovative non-bank finance, would be a worthy beneficiary of credit easing if the Bank of England chooses to initiate such a policy.
-

- Encouraging other major public funds to consolidate so as to provide the critical mass to sustain parts of their portfolio in technology and service innovation. Local government pension funds are one obvious source of capital; the funds controlled by the government Shareholder Executive are another. In both cases government could and should take a lead.
- Encouraging large companies to invest in early-stage businesses. Some UK and international businesses currently possess large cash reserves. These are increasingly becoming a source of capital for start-ups. Corporate venturing has had a mixed track record, with some very poor performance in the Internet boom of the late nineties, but investor capability has been growing, particularly as some firms (for example in the pharmaceutical industry) increasingly see corporate VC as a core part of their product development pipeline.¹²⁹ However, corporate VC is not the only option for encouraging large businesses to finance growing start-ups. Large businesses can play an important role by acting as lead customers for smaller, innovative ones. Innovation brokerages like OpenIDEO or 100% Open (a spin-off from Nesta) can help facilitate this. The government should consider looking at the applicability of existing finance schemes to large businesses. This would include using the Business Finance Partnership to back supply chain finance, and considering whether ECFs could invest in high-quality UK-based corporate VC funds willing to make early-stage investments that involve real technology risk.
- Consulting with the London Stock Exchange, the Alternative Investments Market (AIM) and institutional investors on how to boost the fortunes of our second market: AIM still plays host to listings by innovative companies (this summer saw listings by green energy provider GoodEnergies and polymer designer Revolymer, but volumes are lower than in AIM's heyday). Venture Capitalist Robin Klein¹³⁰ and AIM veteran Stephen Hazell-Smith¹³¹ have both recently argued for tax breaks and a new attitude among investors to make new listings easier.

More patient capital for innovation

If we want start-ups to grow into world-class companies, the Government needs also to take steps to improve the UK's supply of patient capital. The banking crisis, while deeply unwelcome, provides a unique opportunity to do this, partly because so much of the banking system is currently in government hands, and partly because of the Bank of England's ongoing policy of quantitative easing.

We need to first improve the banking system's ability to provide intelligent, patient capital to growing businesses:

- Using credit easing and partial government guarantees to increase banks' capability to lend to businesses. Nesta's Beyond the Banks report and the Nesta-Big Innovation Centre report The Discouraged Economy set out proposals for the government to partially guarantee bundles of bank small business loans, which could then be securitised. This option depends on coordinated action by the Government and the Bank of England: if the Bank reverses its stance against credit easing, money created through quantitative easing could (as former MPC member Adam Posen has suggested) be used to buy these securities, providing much more capital for business loans.

- Giving more operational freedom to the Green Investment Bank, whose operations have been severely curtailed by lack of finance and limited abilities to borrow. Allowing it greater freedom to borrow and combine this borrowing with finance from other sources would greatly increase the financing options for UK green technology companies.
- A more ambitious option is to extend the Green Investment Bank approach to other areas. The taxpayer currently owns a large proportion of the UK's banking sector. Part of this could, rather than being floated in its current guise, be turned into the core of one or more focused industrial banks, aimed at making capital available to fast-growing businesses. This proposal is consistent with the British Chambers of Commerce's call for a 'state-backed business bank'.¹³² A first serious step would be to create a Life Sciences Bank and an Advanced Manufacturing Bank, using an open competitive process to bring together the right combination of existing capital and leadership talent. Such banks would be well positioned to work with the Business Growth Fund and early-stage investors to provide a funding 'escalator' that will give businesses access to both equity and debt finance.

Second, the government should identify and encourage new sources of patient capital:

- Actively seek a UK presence for successful funds from other countries. The recent arrival of the Silicon Valley Bank in the UK is a healthy sign. We need other funds — including Asian and Middle-Eastern capital — to see the UK as an attractive market, just as a generation ago the UK successfully brought in both Japanese manufacturing investment and US investment banks. At the same time, UK regulators should rethink their insouciance about trade sales of UK businesses to foreign investors, in cases where UK supply chains will be undermined or operations removed entirely from the UK. Such sales are likely to hold back the development of patient capital in the UK. A practical step to prevent this would be to require the Competition Commission to consider the effect of foreign takeovers on the UK's long-term productive and innovative capacity, and where appropriate to require binding commitments on capacity as a condition for takeovers to proceed.
 - Work with pensions providers to test out simple ways of giving the public the option of directing a percentage of their pension assets (e.g. up to 5 per cent) into technology and innovation.
 - In the longer term, identify new pools of patient capital. One of the less publicised factors behind the expansion of the VC industry in the US was the existence of significant institutional investors willing to invest in VC funds — in particular, university endowments and large public pension funds. The UK lacks large university endowments, and our public sector pensions are for the most part paid out of current tax revenues. Options to consider include a programme of compulsory superannuation for public sector pensions, creating endowed schemes to fund future pension liabilities,¹³³ using EIS-style tax breaks to encourage more existing institutional investors into long-term asset classes like venture capital, creating retail markets for venture bonds,¹³⁴ or attracting sovereign wealth funds as investors.
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2. A government that focuses on the future

From basic research to educating the workforce, public spending has a major effect on how innovative and productive the UK is. But the majority of public spending does little to boost the UK's long-term productivity. It is the public sector equivalent of a business spending too much on pay and dividends at the expense of investment. If we want to see more innovation and economic growth, this needs to change. In the short term, this requires us to identify discretionary areas of spending and focus them on investment and innovation — the most immediate example being the proceeds from the forthcoming auction of the UK's 4G mobile spectrum. In the longer term, this will require a change in political culture and priorities.

Background

Governments spend their money on many things. Some spending creates an immediate benefit: for example, the running costs of the NHS result in people being treated and cured now; Winter Fuel Allowance keeps people warm now. Others create a benefit in the future: for example, the costs of the school system prepare people to lead more fulfilling and productive lives long after they have left school or university. Science, technology, education and infrastructure are some of the public spending items that most obviously create a future, as opposed to a present, benefit. They might be thought of as 'investment' rather than 'consumption' activities from a national point of view.

'Investment' is not necessarily better than 'consumption', either for households or for governments. A household that spent nothing on consumption would starve and freeze. A government that did not pay disability allowance or the costs of healthcare would be widely reviled. But if the government spends less on investment and more on consumption it is likely to affect our long-term prosperity, just as surely as it would if a household or business were to do the same.

The UK government does not report how much it spends on investment and consumption. (It reports how much it spends on capital investment, but that is not the same thing — the salary of a science teacher does not count as capital investment, but building an asylum detention centre does, even though the former is likely to do much more for future economic growth.)

Since these figures are not available, we estimated them, using Public Expenditure Survey Analysis data for the last five years. This suggests that investment accounts for a minority of government spending — around a sixth — and perhaps more worryingly that this number has been falling in recent years¹³⁵ (see Figure 13).

These trends are partly a function of smaller, directly observable changes: fiscal contraction has involved significant cuts to the funding of university education, and smaller cuts to school education, while spending on some 'consumption' items, notably healthcare, has been protected, and the cost of transfer payments such as jobseeker's allowance and debt service has increased. Some of these changes reflect the effects of the economic downturn and the policies taken in response to it. But the broader trend towards more 'consumption' spending is one that has caused concern in other countries as well as the UK.¹³⁶

It is telling that even when additional spend has been made available for technology and innovation in recent years, it has been dwarfed by the amounts allocated for discretionary 'consumption' spending, as Figure 18 shows.

International comparisons are harder to make given the levels of variation in the data, but focusing on a particularly important type of investment in the future, public R&D, suggests that other innovative countries are outpacing the UK (see Figure 4).

PROPOSALS

Changing the UK's public spending priorities is not a task to be undertaken lightly. But there are both short-term and long-term measures that can be taken to redress the balance between consumption and investment.

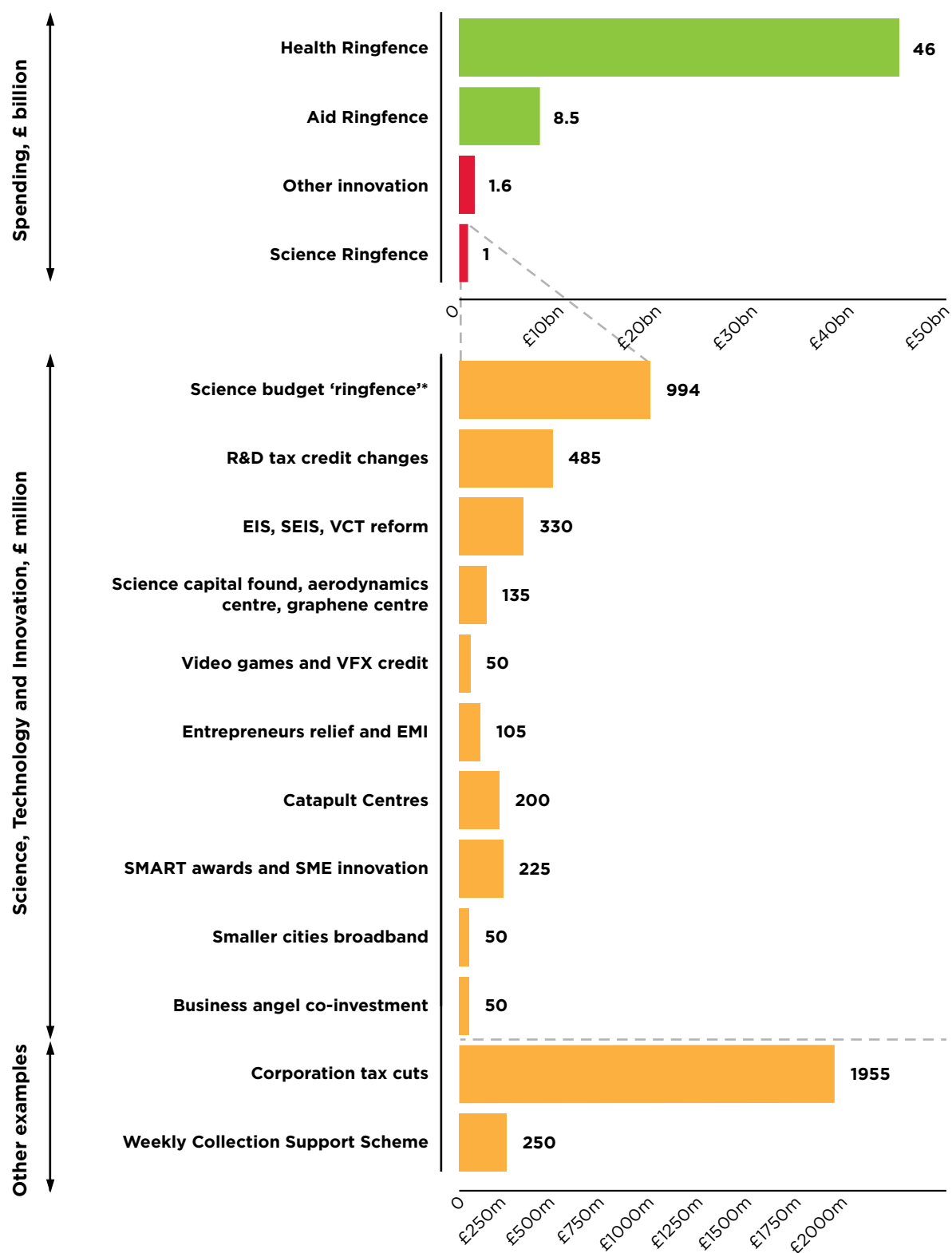
Investing 4G auction funds

In the short term, government should look for opportunities to invest in economic growth when windfalls and exceptional items allow. The most obvious example is the planned auction of the UK's 4G mobile spectrum, which is expected to start by the end of 2012. The sum that this is expected to raise (between £3 billion and perhaps £4 billion) could make a material difference to technology and innovation in the UK. Over the coming months, Nesta and the Campaign for Science and Engineering will be mounting a campaign to ensure the proceeds from the 4G sale are reinvested into science and technology. The 4G receipts are a windfall from past investment in innovation; it's only right that a high proportion of the benefits should be reinvested in future wealth (see p.63).

Reset government spending

In the longer term, a more strategic approach is called for. Government spending priorities are set in response to political pressures. If we want government to take spending on science, technology and education as seriously as the running costs of the NHS or the cost of weekly rubbish collection, people who believe in innovation need to stand up and make their voices heard, and to argue strongly for a shift in spending from government consumption to government investment. A half-percentage point shift would triple how much the UK spends on translational research. A single percentage point would double public spending on research. Two percentage points would double what we spend on primary age education. These are worthy goals for a country that believes in its future, and perhaps, tests whether our political culture fundamentally sees the UK in a slow retreat and decline or whether leaders have confidence in the future.

Figure 18: Discretionary government spending on science, technology and innovation, 2012/13 to 2014/15



Source: Budgets 2009, 2010 (x2), 2011, 2012, BIS Research and Innovation Strategy, TSB

*Difference between planned expenditure and average spending consolidation of other departments

HOW TO SPEND MONEY FROM THE 4G SPECTRUM AUCTION

Later in 2012, the UK is scheduled to begin the process for auctioning off the 4G wireless spectrum to mobile operators. It has been estimated that this sale could raise between three and four billion pounds.

Together with the Campaign for Science and Engineering, Nesta is campaigning for this money to be reinvested into innovation, technology and science. This would offer an immediate way to start redressing the balance in government spending from consumption to investment in the future.

The proposal has a strong sense of poetic justice: without the efforts of generations of innovators, many of them British, from James Clerk Maxwell and Alexander Graham Bell to Joe McGeehan and Jonathan Ive, there would be no reason for a spectrum auction.

A £4 billion windfall could form the basis for a fund to be invested over the next five years to maintain the UK's innovative edge. Examples of what such a fund could pay for include:

Talented researchers & innovators

Examples: Developing the equivalent of Canada's Excellence Research Chairs programme (which attracts talented scientists and engineers from around the world and builds research teams around them). Providing early-career fellowships for researchers. Funding exchanges between business and academia.

£500m

Investing in tech infrastructure

Examples: Funding science and technology capital expenditure, including research facilities like the new graphene and high-performance computing centres, to technological demonstrators like Belgium's IMEC or the Wilton industrial biotech centre in areas of UK innovative strength.

£1.5bn

Grand technological challenges

Examples: Funding grand challenge prizes as described in recommendation 6, and deepening business-university links, for example through an expansion of the Catapult programme.

£1bn

Backing entrepreneurship

Examples: Setting up the £200 million early-stage co-investment fund outlined in recommendation 1. Co-funding accelerators and backing new models of early-stage support.

£1bn

3. Investing in infrastructures

There is widespread agreement that more investment in infrastructure is part of the answer to the UK's economic problems. Infrastructure investment raises productivity in the long run, and in the short term the construction is a source of economic stimulus. But all too often the debate on infrastructure focuses exclusively on roads and railways. We argue that any infrastructure investment programme should not just focus on nineteenth and twentieth-century infrastructure in the form of road, rail and airports. It must also prioritise the infrastructures of the twenty-first century: high-speed broadband and smart electricity grids. And it must make room for a much older form of infrastructure: housing, in particular the provision of housing around the UK's emerging tech clusters.

Background

Across the political spectrum, politicians and pundits have argued that the UK should invest in infrastructure to help revive the economy. Within government, both the Chancellor of the Exchequer¹³⁷ and the Deputy Prime Minister¹³⁸ have argued for a programme of infrastructure investment. And among those who argue for Plan B, infrastructure spending ranks high on their list of priorities.¹³⁹

Infrastructure spending in a downturn is appealing for three reasons: done well, it increases long-term productivity; in any case, the wages paid to the people who build it help stimulate the economy in the short term; and in many cases it needs to be done sooner or later anyway, so doing it when borrowing costs are low and when there is slack capacity in the economy makes sense.

But when infrastructure is mentioned, the debate normally narrows down to one type of infrastructure: transport. The three highest profile infrastructure projects are Crossrail and High Speed 2, costing £16 billion and £33 billion respectively, and the third runway at Heathrow, which involves no cost to the taxpayer but is vastly politically controversial.

This is a shame. Although the UK could certainly benefit from better transport links, there is more to productivity than planes, trains and automobiles. Some of the most exciting breakthroughs we might expect to see in the decade or two to come depend on other types of infrastructure: in particular, superfast broadband, smart grids for power, and more housing and office space around emerging clusters.

Broadband, and in particular super-fast broadband (which delivers speeds of 100 megabits per second and more) is the twenty-first century equivalent of the motorway system. When the first wave of broadband was deployed in the 1990s and 2000s, it enabled great leaps in productivity as businesses, especially in the retail and business services sector, changed their processes and supply chains to take advantage of a steadily increasing flow of data about their operations. Technologists like Brian Arthur and George Gilder have argued that this is just the beginning: increasing bandwidth will drive a new industrial revolution, as far more technology is delivered remotely and far more 'real-life' economic activity is mediated by computers, driving demand for ever more bandwidth.

The travails of internet start-ups in East London, who have reported frustrations with the internet connections in the UK's 'Tech City' may be the first rumblings of much greater demand for bandwidth. Bandwidth usage in the UK increased by 50 per cent in each of the last five years.¹⁴⁰ A recent survey for the government's e-infrastructure working group found the vast majority of startup and SME respondents asking for more widely available high-speed fibre and connections; upload capability is particularly important for many businesses, and considered particularly lacking. (In the UK, a version of superfast broadband is gradually being deployed by BT and Virgin Media. Typically this takes the form of fibre-to-the-cabinet, relying on old copper wires to provide the final connection to the home. This can provide a speed of around 80 megabits per second, compared to 300 or more megabits per second for fibre-to-the-home technology.)

Other countries show us what can be done in this area. Korea has spent \$25 billion in deploying superfast broadband, an investment that has helped make it a global hub for the development of video games, new online services, and cloud computing.¹⁴¹ Australia has pioneered a public-private model for the deployment of broadband, in which the government commissioned private contractors to build a broadband infrastructure that it then leases to private operators. The ITU, the global telecoms authority, has praised this structure, arguing that it has resulted in faster broadband rollout than had the private sector been left to finance broadband itself, at a reasonable cost.¹⁴² Working with private sector contractors also avoids the problem of the government picking the particular technology to be used to provide the infrastructure, which it may not be best placed to do — indeed, it is likely that different technologies and architectures will be suitable for different areas.

Public investment in broadband should be seen as strategic investment. If superfast broadband is rare, it is unlikely that any individual business will adapt its ways of operating to take advantage of it, and few producers will bother to create services that exploit its potential. If it is widely available, the benefits increase significantly. We do not fully know what applications superfast broadband will give rise to: at the moment, few applications make use of the gigabit-per-second connectivity that fibre-to-the-home provides.¹⁴³ But if the history of the last 30 years has taught us anything, it is that people and businesses find ingenious uses for more memory, more processing power, and more bandwidth. It was not so long ago that Bill Gates opined that 640k of memory would suffice for most computer users.¹⁴⁴ Looking further back, the American Interstate system and the German Autobahns were built long before there were enough cars to fill them. Like these projects, superfast broadband is an investment in the future.

The idea of the **smart grid** is to use the power of information technology to create an electrical grid that responds automatically to user demand and that can draw on multiple sources of energy (including households), increasing reliability and reducing cost and energy consumption. As well as helping the UK meet its goal of reducing carbon emissions, a smarter electricity grid would, it is thought, generate large savings by reducing electricity consumption; a recent report by Ernst & Young estimated the net present value of these savings at £19 billion between 2012 and 2050, net of the cost of smart grid deployment.¹⁴⁵ Earlier research by McKinsey & Company argued that increasing energy efficiency generally was the most effective means of both saving money and abating carbon emissions.¹⁴⁶

The cost of deploying a smart grid is, of course, the barrier. Currently, the UK's cost-based electricity regulatory regime provides limited incentive for private electricity firms to invest either in smart grid technology or the smart meters required in homes. So far, the UK has offered a number of small research grants for smart grid projects, and has provided

some support through the TSB. The US, in comparison, has taken a much more active role in encouraging smart grid deployment, providing a \$4bn coinvestment fund for energy companies deploying smart grid technology.

Housing and office space may seem less glamorous than broadband, but are just as important for innovation. Nesta's work on innovative clusters around the UK showed a number of examples, from Cambridge to Southampton, where planning laws and usage restrictions made it hard for emerging tech clusters either to expand or to provide housing for the workers for whom they were creating jobs.¹⁴⁷ Research by Paul Cheshire of the LSE noted that regulatory barriers meant that the office space in British cities was far more expensive than in their American equivalents.¹⁴⁸ Five decades of governments around the world trying to create high-tech clusters from scratch has taught us that clusters grow best organically — so it is a tragedy that our planning rules make this more difficult. Instead, we should be making it easier for innovative areas to expand, and for people to move to them.¹⁴⁹ An infrastructure policy that put innovation at its heart would seek to remove the barriers for developing houses and office space in the places where innovation is creating jobs.

It is difficult to compare directly the benefits of these types of infrastructure. Transport projects have the convenient and comforting characteristic that their economic benefit can be neatly measured by clever economic consultants: Crossrail will supposedly bring £42 billion of value, HS2 £43 billion. The effect of housing development that allows clusters to thrive, or of deploying broadband that allows new business models to take hold, or of rolling out smart grids that may transform the way we use energy, is much harder to model. Indeed, there is considerable controversy even over the benefits of existing investments in broadband, with some economists arguing the effects have been vast, others that they have been relatively small. But in all three cases, the potential upside is considerably higher than the mostly incremental effects of upgrading existing transport routes. If our aim is economic transformation, this is an important consideration.

But broadband, smart grids and housing have other appealing characteristics. Housing investment has a particularly strong short-term effect on the economy in addition to its long-term productivity benefits: since much of it goes on wages, which are spent domestically, and little is exported. By taking a lead on smart grid deployment, the UK's energy industry will develop expertise that will be in demand around the world.¹⁵⁰ Broadband has the advantage that it starts to yield a productivity benefit almost as soon as work begins (as the first houses or offices are connected), unlike new rail lines, which cannot be used until they are finished.

PROPOSALS

This suggests that any programme of infrastructure investment should not focus exclusively on transport, but should include three vital elements that foster innovation:

Superfast broadband. The government should borrow to invest in the creation of a superfast broadband network around the UK. The costs of deploying fibre-to-the-home broadband to the whole of the UK has been estimated at £15 billion,¹⁵¹ less than half the cost of High Speed 2. A parsimonious option would be to start the deployment in a limited number of urban and rural areas, at a cost of perhaps £5 billion, to reduce initial costs and learn lessons for wider deployment.

This investment should take the form of contracts issued to the private sector to develop broadband infrastructure to an agreed speed on an area-by-area basis. This will avoid the problem of government choosing a single, perhaps inappropriate or obsolescent technology, and will involve a range of providers in the deployment (including, we hope, emerging community broadband providers¹⁵²). Government will then lease access to the infrastructure to service providers on a competitive basis.

This should be combined with small business support from the Technology Strategy Board for the development of applications to make the most of superfast broadband. Nesta's Hyperlocal Media programme, which is being matched by the TSB, is an example to build on.

Smart grids. Alongside the broadband investment, the government should put in place a £5 billion smart grids fund to be used to match investment by electricity firms or new entrants in smart grid deployment. The work of the Technology Strategy Board (TSB), the Department of Energy and Climate Change (DECC), Ofgem and SmartGrid GB offers a strong basis for designing the fund and ensuring its effectiveness in encouraging business investment.

Cluster infrastructure. The UK's infrastructure plan should also remove the barriers to the development of housing in areas where it is in most demand — typically in areas where the economy is thriving and innovation most active. Lifting green belt restrictions in areas of strong economic activity would have significant benefits for innovation. It would allow growing businesses to expand, both directly where office space is at a premium, and indirectly, by reducing the cost of housing for workers and thus making it easier to hire them. It is also likely that this would unleash considerable private sector investment, since housebuilders like to build in places that are prospering. Under proposals such as Tim Leunig's plan for community land auctions, such a policy could also raise money for local residents and councils.¹⁵³

4. Government as a customer for innovative businesses

Often the best early help an innovative business can have is a good first customer. For years, policymakers have tried to put the government's £220 billion procurement budget to work to buy new products from innovative firms, but with limited success. We argue that to make this work, government needs to set up an innovative procurement organisation that draws its inspiration from the US's DARPA and SBIR programmes, funded by a small proportion of each department's procurement spending. But government money is only part of the answer. Government has also a role to play, alongside businesses and academics, in identifying long-term technological needs, and using standards, procurement, and joint work with industry to address them.

Background

Some of history's most successful innovations have depended on a supportive first customer to get them going. Such 'lead' customers do not just provide money to invest in product development: they also provide insight into customer needs, a strong incentive to develop and then improve a product, and a source of credibility for future sales. Perhaps the best known example is Microsoft's early contract with IBM to develop MS-DOS, but there are many similar cases: a crucial early break for the software giant Autonomy came when its predecessor firm, Neurodynamics, was commissioned to develop fingerprint-matching software for a police force,¹⁵⁴ while the UK's leading semiconductor firm, ARM, can trace its origins back to the contract granted by the UK Department of Industry to Acorn Computers to design the BBC Micro.¹⁵⁵

When we think about who has the money to play this kind of role in the UK, two numbers immediately spring to mind: the £750 billion of cash sitting on UK businesses' balance sheets, and the £220 billion the government spends every year on buying goods and services. Let us consider both these potential customers in turn.

Large UK businesses as lead customers. The UK plays host to a long list of world-class companies, both in the tech sector and beyond. Some of these businesses, such as our large pharmaceutical companies, are keen funders and customers for innovative smaller businesses. And its status as the world's biggest provider of foreign-funded R&D shows that overseas firms also look to the UK for ideas.

However, in some sectors, innovations developed by smaller British firms have trouble finding commercial customers in the UK. Biotech companies frequently discover that the only companies willing to license and develop their technologies are based overseas, and the history of technology contains many examples such as Inkjet printing where the discovery or significant early research was done in the UK, but commercial benefits mostly ended up overseas. And of course, at least some businesses in the UK and beyond have in recent years had unusually large cash reserves, which may give them more flexibility than usual to take a risk on new suppliers or to invest in smaller firms.

There are a couple of developments that make this easier for large businesses to countenance. First, the resurgence of corporate venture capital, which had been pared back severely after the dot-com crash of 2000. More large businesses are seeing direct investment in smaller innovative businesses as a good way to get access to new ideas and

new growth opportunities. Not all of these programmes are willing to invest at the early stage, however, or to take significant technology risk — but we may see this change over time.¹⁵⁶

Second, better tools and practices for open innovation: the emergence of people and businesses skilled at sharing knowledge between small and large firms in a way that both parties benefit. Businesses like InnoCentive and 100% Open have done much to build constructive relationships between big and small, and to encourage corporate giants to act more often as lead customers.

Helping these trends to flourish is an essential part of encouraging more lead customers for innovation in the UK.

The public sector as a lead customer. For many years, policymakers have tried to get government to play a lead customer role — indeed, it has become something of a Holy Grail of innovation policy. After all, government procurement is big money. The UK state spends around £220 billion a year buying goods and services from businesses. If just half a per cent of this budget found its way to innovative start-ups, it would exceed the annual investments of all UK venture capital funds.¹⁵⁷

Aside from the sheer amount of money involved, there are two reasons this policy is so alluring. Firstly, there are a range of compelling examples of what happens when it works. The most famous are longstanding American programmes like the Defense Advanced Research Projects Agency (DARPA) and the Small Business Innovation Research Programme (SBIR). DARPA famously gave rise to the Internet, unmanned aerial vehicles and other wonders, while SBIR backed successful companies such as Qualcomm, Amgen and Genzyme in their early days.¹⁵⁸ The examples are not limited to the US. We've already mentioned the role of the BBC Computer Literacy Project of the early 1980s in procuring the BBC Micro for use in schools, which played a role in the rise of Acorn and in due course, the establishment of ARM, currently the UK's most valuable technology company.¹⁵⁹

Secondly, using procurement to promote innovation looks a lot like a free lunch for the taxpayer, or at least a discount one. If a given procurement would have gone ahead anyway, and it can help promote an innovative business rather than an incumbent, so much the better. Some procurements will fail or will result in poor value for money, of course. But in other cases, it is argued, an innovative solution could be better value for money than business-as-usual.



Successful SBIR candidate, Oxford-based startup Eykona Technologies' novel 3D technology assesses how chronic wounds are healing. Having closed significant investment rounds in 2009, the Eykona device was purchased by a number of Trusts in England after a series of successful NHS trials in late 2011.

It should come as no surprise that there have been a number of attempts to get the UK government to procure 'for innovation'. The best known of these is the Small Business Research Initiative (SBRI), a programme run by the TSB where participating departments are helped to run a competition to obtain unorthodox solutions to tricky requirements. The programme, which was inspired by the US SBIR programme, has been running for three years in its current form, and was recently boosted by a £150 million pot of top-up funding. The TSB has run a variety of other programmes aimed at helping departments procure innovative solutions, while others have been the responsibility of BIS, most notably the Forward Commitment Procurement programme, which encourages departments to specify long-term specifications for projects, along with a promise to purchase from suppliers that can meet them. The Prison Services' contract for a zero-waste mattress is a frequently cited example of this kind of project. The Cabinet Office's Innovation Launchpad project sought to attract solutions for government business problems from small businesses, to provide the businesses with mentorship, and to connect them to procurement opportunities.

There have also been calls for more wholesale change: the House of Lords Science and Technology Committee called in 2011 for innovation to be put at the heart of procurement, and for procurement officials to be trained in how to recognise and assess innovative tenders. An earlier attempt to do this involved BIS requiring departments to construct Innovation Procurement Plans (IPPs), setting out their likely future needs, but these had little traction, and lacking measurable objectives, the Lord's committee described them as "little more than a statement of good intentions".¹⁶⁰

There are two main reasons why progress on this subject has been slow, even though the importance of procurement to innovation is widely acknowledged.¹⁶¹ The first reason is inertia. Transforming the behaviour of thousands of procurement officials across government is, like any major change project, very hard.¹⁶² The second reason is that procuring for innovation is not always as cost-free as it looks. If it encourages officials to buy a more expensive product that turns out to be no better than the off-the-shelf option, or if the risks inherent in picking an innovative solution result in the government receiving goods or services that work badly, procuring for innovation may be more expensive than the alternative. This is particularly true where there are tried-and-tested solutions available to meet a particular need. More generally, if managerial bandwidth is limited, a drive to encourage officials to think about innovation when making procurement decisions may distract them from focusing on value for money. These incentives are especially powerful when amplified by the public sector's inherent risk aversion: the downside of a failed project is far greater than the upside of a successful, innovative procurement, thus encouraging the safe option.

All this means that such programmes that exist remain small-scale. SBRI accounted for £27 million in 2010, and 425 contracts,¹⁶³ and it will require a significant increase in interest



IMAGE COURTESY OF INNOCENTIVE

Since 2001 InnoCentive has registered over 250,000 'solvers' from 200 countries

from departments (who make the decision whether to use SBRI for a given project) if it is to grow fast. All of this is a far cry from the \$5.3 billion that flows through DARPA and SBIR every year. What can be done?

PROPOSALS

Government as a lead customer. If we are serious about bringing the weight of the government's purchasing power to bear on innovation, we need to see a dramatic increase in the proportion of procurement budgets focused on innovative goods and services. But at the same time, we need to be conscious that most procurement is of run-of-the-mill products where there may be little scope for innovation, and taxpayers' interests are best served by procuring from the cheapest credible supplier.

Rather than attempting to change the behaviour of all agencies and officials responsible for procurement, the way around this is to follow the example of DARPA and the SBIR in the United States and establish a dedicated organisation for the procurement of innovative solutions for government requirements: specifically, we propose an 'Innovation Engine' for government procurement. HM Treasury should mandate that a fixed proportion of each department's allocation, say 1 per cent, be channelled into this organisation. Its twin aims should be delivering exceptionally innovative solutions for public service challenges, and developing the innovative capacity of the UK.

The point of establishing the Innovation Engine outside of existing departments' procurement teams is to make it a centre of expertise for procuring genuinely innovative solutions to difficult departmental problems, with a deep knowledge of technology, service design and working with start-ups and small businesses. However, it should work closely with departments, treating them as its customers and adding value by helping them identify their future needs and communicate them to suppliers and researchers. (One institutional option is to place it under the remit of the TSB, which currently runs the SBRI programme, but others may come forward with alternative ideas and some institutional pluralism is desirable). Like DARPA, the Innovation Engine should be divided into subgroups with functional expertise — these may well cut across the work of more than one government department, making it easier for the organisation to identify solutions beyond departmental boundaries.

The other lesson to be learnt from DARPA is the leanness of its operations. DARPA is sometimes criticised for its size and profligacy. But it is a relatively small organisation given the amount of funds at its disposal, and it often manages its networks exceptionally well. In particular, it has a reputation as a tough contract manager, and a relatively porous organisation, with programme managers joining from and leaving to academia and the private sector regularly (the typical tenure of a DARPA technical staffer is three to five years). This staffing model keeps DARPA project managers close to the cutting edge, and more willing to take risks than departmental lifers.

It is also an innovative funder: it is a long-standing exponent of challenge prizes (see recommendation 6: Incentives for Innovators), funding early work in the development of self-driving cars through the 2004–2007 DARPA Grand Challenges. There is scope for further exploration in how challenge prizes can be combined with other forms of support.

Setting up the Innovation Engine is bound to be controversial. At a time when departmental budgets are being squeezed, putting even a small proportion under the

control of another organisation is likely to be painful for departments and will encounter resistance. But the benefits of encouraging more radical thinking on how to meet the toughest government challenges, while at the same time massively increasing the resources available for innovative businesses in the UK, are hard to pass up.

Standards and regulation. Channelling public procurement towards innovative businesses is a direct way that the government can encourage innovation, but not the only one. Public bodies already take responsibility for setting standards and regulation for a wide range of products. While much regulation discourages innovation, there are a number of important examples where the opposite is true. These should form a central part of public policy to promote innovation. Environmental regulations are the most obvious example of rules that, if implemented effectively, can create opportunities for innovation;¹⁶⁴ examples include California's Low Emission Vehicle Programme, which encouraged the production of low-emission cars, or Denmark's drive to implement wind power in the 1970s, which laid the foundations of Denmark's thriving wind turbine industry. Experience in Europe and the US suggests that these kind of regulations have the most positive effect on innovation if they are clear, long-term, and backed by the commitment of government.

Standards have an equally important role to play in helping innovative businesses settle on a dominant type of technology, which increases the scope for outside investment and acts as a platform for further innovation. Familiar technologies such as Wi-Fi and Bluetooth have depended on agreed standards for their widespread deployment.

One intriguing area for standard development in which the UK could plausibly take the lead relates to financial services. Andy Haldane, the Bank of England's Executive Director for Financial Stability, recently argued that better information standards in the financial services industry could make it far easier for banks to keep track of complex assets and liabilities, and could significantly simplify the financial system.¹⁶⁵ These standards would be the equivalent of bar codes in the retail sector, without which it would have been impossible to computerise supply chains — a change that led to very large productivity gains across the whole economy in the 1990s and 2000s. Haldane has argued that this kind of standard would make it much easier and safer for new businesses to provide financial services, potentially breaking banks' privileged position, and benefitting customers and ordinary businesses. Given the importance of the financial services sector to the UK and the importance of London to the world's markets, this is an area where new thinking about standards could give the UK a significant innovative edge.

IMPROVING OUR INNOVATION SYSTEM

With greater flows of finance, the next priority is to ensure the innovation system works better. This means improving the flows of knowledge and information around the economy, creating the right incentives for innovation, and paying special attention to areas in which the innovation system is not working as well as it could, for example in many regions of the UK outside the south east, in the public sector or in the labour market. It also means strengthening the quality of data gathered on innovation and evaluating more rigorously which innovation policies are working.

5. Fostering ‘collective intelligence’

Ideas often develop as combinations and hybrids, which is why innovation so often depends on networks that connect researchers and inventors, businesses and the wider world. The rapid evolution of digital technologies and networks has made the ability to orchestrate knowledge, and to manage creative interactions a central issue of economic policy. The social and technological tools for combining and analysing information and understanding from different individuals, fields and organisations are forming a new domain of knowledge and practice: collective intelligence.

The tools of collective intelligence include new technologies for sharing data and knowledge, such as crowdsourcing platforms, and novel research metrics (known as altmetrics). They include analytic tools that allow vast amounts of complex data, often from different sources, to be understood, a field pioneered by Cambridge-based Autonomy. They include decision tools, collaboration tools and tools to support judgement. And they include the everyday innovations that underpin joint working, such as sandboxes and hackdays that bring together researchers and coders from different disciplines.

In an age of ‘combinatorial’ innovation — where major breakthroughs are likely to involve knowledge from different fields and joint working between thinkers, doers and communicators, being good at collective intelligence will be a crucial determinant of success for businesses, for governments, and for countries. Understanding more about how collective intelligence happens, and devising and implementing effective tools for fostering it should be a major project for the UK in the next decade.

Background

Human beings have collaborated to innovate and solve problems since time immemorial. Although the term ‘open innovation’ was popularised in the 2000s, the concept can be seen in the artistic developments of the Renaissance, the engineering breakthroughs of the Industrial Revolution, or the shipyards of Glasgow and Tyneside in the nineteenth century. But two forces are changing why and how collaboration happens.

First, the progress of human knowledge. The more that human beings know, the more new discoveries and developments will rely on the blending of existing ideas. This will require collaboration.

It's said that the last person to be at the forefront of all fields of human knowledge died in the Enlightenment: human knowledge has simply become too complex for this to be possible any longer. This complexity continues to increase. The economist Ben Jones showed that the age at which Nobel Laureates made their most significant discovery has steadily increased, as researchers need to train for longer and longer to reach the cutting edge in their field. Erik Brynjolfsson and Andrew McAfee have argued that as more and more discoveries are made, economic growth will depend on 'combinatorial' innovation — combining ideas that already exist into new forms, or combining new ideas with old ones.¹⁶⁶ Innovation scholar Brian Arthur has described this combinatorial process as the heart of all innovation. The complexity of a modern manufactured product like the iPod, which combines hard-disk technology, the MP3 protocol, an international supply chain, and an online system for buying and downloading music, bears this out.

The second factor changing the nature of collaboration is the growing power of ICT. The internet provides an ever growing range of platforms for people to collaborate, and share knowledge and problems. Innovations like Kaggle, which draws on the expertise of data scientists around the world to develop algorithms to solve business and research problems would have been impossible a decade ago. ICT also provides the power to draw together and understand data without human intermediation. Autonomy made Britain the world's centre of the analysis of unstructured data (the vast majority of information on the world's computer systems that is often text-heavy and irregular and doesn't fit neatly into databases for processing). Businesses like Quid and Palantir crawl the Web to analyse tech trends and security threats, and data science more generally is considered a hot trend in business and technology.

These changes are putting a premium on how well we collaborate, and are leading to the rapid development of social innovations to aid collaboration. But the field of collective intelligence is still very much in its infancy. The state of the art in data science and analytics changes month by month. We are also seeing a period of vibrant innovation in the social norms of collaboration. The explosion of hackdays, unconferences, sandboxes and accelerators, or the huge impact of the Open Science movement in the last ten years is a sign of the vibrancy of this field.

But even in relatively mainstream aspects of collective intelligence, such as academic collaboration, there is a limited certainty about 'what works'.¹⁶⁷ All this should change with time — it will become clearer what is working in business acceleration, cross-disciplinary research, and innovative team-working, especially as data collection and tracking on these processes improves. Data science and analytics will continue to develop in leaps and bounds, spurred by huge business interest and ongoing investment from academics and public research budgets.

But there will be an advantage for businesses, countries and economies that can put themselves at the forefront of this, both by maximising their expertise in collective intelligence and by making sure their public policies, in particular research funding systems, let collective intelligence flourish. In many of these aspects, the UK starts from a strong position (see box).

THE UK'S ANALYTIC EDGE

It's no secret that the ability to gather and analyse huge volumes of data is revolutionising fields from marketing to healthcare. 'Big Data' and data science offer the ability to make sense of out of information that would previously have been regarded as junk.

Data science is one of the key components of collective intelligence. Britain already plays host to some market-leading businesses in this field. Autonomy, the Cambridge-based software giant recently acquired by HP, is the world leader in the analysis of unstructured data. It has given rise to a variety of exciting start-ups like Aurasma and Blinx. The Cambridge Signal Processing Lab, where Autonomy's founder Mike Lynch conducted his PhD research, has given rise to other analytic startups such as genetics firm BlueGnome, audio data restoration business CEDAR Audio and the behavioural analytics company Featurespace.¹⁶⁸ Dunnhumby, now part of Tesco, has been crunching data from the retailer's Clubcard programme since 1995, and has built up an incomparable reputation in both the UK and the US for deep customer understanding; while London-based Trampoline systems has developed deep expertise in social analytics for businesses.

These businesses draw on particular aspects of UK expertise: in particular the combination of strong academic computer science departments and an innovative businesses services sector. Last.fm, a data-driven music service and prominent success-story of Silicon Roundabout, was built on technology from the University of Southampton. It is perhaps no surprise that major venture capital firms have invested in UK 'big data' companies, from Index Ventures (last.fm, EDITD) to IA Ventures (DataSift). UK-based Dawn Capital, founded in 2007 by a team of entrepreneurs and venture investors, has invested in a number of start-ups focused on data analytics, including Cognitive Match, which applies machine learning to marketing and Wonga, whose loan approval is based on sophisticated data capture and analysis. They recently raised a second fund, which may be an indication of more investments in this space.

There are several aspects of collective intelligence where public policy can make a difference to the UK's fortunes.

Collective intelligence can be encouraged — or discouraged — by the rules that the Government sets up over access to data; the incentives placed on academics who received public funding, the state of research into not only data science and machine learning, but also the social science of collaboration; and the career structures of researchers. There are also public schemes that directly promote collaboration, in particular voucher schemes that co-fund businesses to work with universities or the Higher Education Investment Fund (HEIF), which pays for university-business collaboration and tech transfer. The European Commission is developing ambitious programmes to support new platforms for collaboration, with a particular focus on complex challenges such as ones involving behaviour change. These sit at the intersection of new technologies, new models of organisation and insights into psychology.

PROPOSALS

There are several steps the Government should take to help the UK take the lead on collective intelligence.

Supporting open data and science

The Government's commitment to open data has been a big step in the right direction, providing a wealth of valuable data that businesses and citizens can access, mash up and analyse.

But there is scope to do more: opening up publicly-funded academic research is the logical extension of the open public data movement. The Government should endorse the recommendations of the Royal Society's 'Science as an Open Enterprise' report,¹⁶⁹ including ensuring that publicly funded research and data are made freely available and can be reused by others for further research.

Funding research to improve collaboration

The incentives placed on universities by public funding rules, and in particular the Research Excellence Framework (REF) are a major influence on how research takes place. There is evidence that ranking and assessment processes like the REF are biased against interdisciplinary research. Recent research showed that interdisciplinary papers in the social sciences were likely to be less highly scored for the purposes of the REF than single disciplinary ones of an equivalent quality, a bias which is concerning given the importance of interdisciplinarity to disruptive innovation.¹⁷⁰ There is also increasing evidence that some university tech transfer offices focus on spin-outs and the licensing of IP to the exclusion of more informal interactions with businesses.¹⁷¹

The next iteration of the REF gives an opportunity to pause for reassessment. An urgent priority should be to improve the REF so that it no longer discourages interdisciplinary work and to ensure that HEIF does not push university tech transfer offices into an unhelpful focus on a limited set of activities. If this is not possible, then we need to ask more fundamental questions about the continued usefulness of the REF as an incentive for researchers.

Promoting innovation in universities themselves

A more radical step would be to ensure that a portion of public funding for higher education supports radical new models for the creation and spread of knowledge. In other fields we expect innovation to depend on new entrants, bringing with them new models. It's a paradox that in the very fields most central to innovation, funding is monopolised by incumbents, making it very difficult for radical new models to thrive (the biggest exception to this rule is the Open University, which recently celebrated its 40th anniversary).

Other countries have done more to push the boundaries, with the deliberate encouragement of new types of university based on insights into the future evolution of collective intelligence — from Aalto University in Finland to the very successful Postech in Korea. These have emphasised both deep disciplinary knowledge and intensive cross-disciplinary collaboration; they have encouraged interactions between formal knowledge and practical knowledge; and they have encouraged relationships with industry and other clients. If the UK is to be serious about collective intelligence, we need to create some places where novel approaches to knowledge creation can be tested out.

Putting collective intelligence at the heart of Catapults

The new Catapult centres being developed by the TSB are intended to improve the links between academics and businesses, so that more of the UK's technological breakthroughs will be developed and produced in the UK. The design of the centres is being left for the most part to the universities and businesses submitting proposals. While it is good that technical and business experts are guiding the development of the centres, there is the risk that the crucial social dynamics of the interaction between business and research will be neglected in the design process.

The TSB should take the opportunity to involve experts on human interaction in the process: architects, designers and the managers of accelerators have all developed deep craft knowledge in this field. The idea of a Catapult centre designed with the help of organisations like architects 00:/ or the team from Seedcamp or Google Campus would be a major step forward for collective intelligence.

Encouraging 'boundary spanners' between research and practice

Most knowledge exchange is in fact people exchange. But career paths in academia, big business and small business are often incompatible, limiting unnecessarily the ability of talented people to cross boundaries and spread useful knowledge.¹⁷² Examples of good practice exist, such as the Wellcome Trust Translational Medicine and Therapeutics Scheme¹⁷³ or the fellowships run by the Interuniversity Microelectronics Centre (IMEC) in Leuven,¹⁷⁴ all of which use training and professional development as a way of bringing individual researchers and managers across the divide between businesses and research organisations. Knowledge Transfer Partnerships are another widely-praised tool that can help bridge the divide. Research Councils should work together with universities and research-intensive businesses to identify more ways to allow people to move between academia and industry without compromising their careers.

Research into collaboration itself

If collective intelligence will be a defining factor of innovation in the future, the UK needs to understand how it works. The government, together with research councils and the TSB, have taken some measures to do this already. From a technological point of view, the new High Performance Computing centre will improve research requiring high-end analysis. And Computer Science remains relatively well funded by the EPSRC. But there is more that can be done.

In particular, Research Councils should recognise that to encourage the most effective types of collaboration is one of the defining social science questions of the next decade, and resource it accordingly. There is valuable work to build on in this field (this includes a wealth of papers in the journal *Research Policy*, Ismael Rafols's research on interdisciplinary research or Gary Dushnitsky's analysis of crowdsourcing and crowdfunding¹⁷⁵). Projects like Google Campus, with interests both in analytics and in fostering collaboration, offer great proving grounds for this research. All collaboration involves some opportunity costs: we need much better insights into which types deliver the greatest returns.

Funding for cross-disciplinary working

Various funds exist to support joint working to encourage innovation — HEIF encourages universities to build links with businesses, while a variety of innovation voucher schemes encourage businesses to work with universities. But these programmes are often small scale and local, and not well evaluated.

The Government should consider merging them into a programme with critical mass, whose aim is to encourage collaborative working with a focus on business needs. The aim should be to encourage not just joint working between universities and businesses, but also between small businesses and large businesses, and between groups of businesses and other innovation intermediaries like designers. Nesta's digital R&D fund for the arts, which links arts organisations, digital technology organisations, and researchers, is a good model of how more creative partnerships can be encouraged, along with rigorous measurement of what works.¹⁷⁶

Finally, the Government should also look closely at the seemingly minor rules and regulations that discourage collaboration and collective intelligence. A prime example of this is the VAT restriction on buildings used by charities (including universities and research organisations), who are unable to host commercial spinouts of their work in the same building. If more than 5 per cent of the building is used for these commercial activities, the entire building and all its activities become liable for VAT. Equally, Research Councils are unable to fund research conducted with businesses, even if the research in question would otherwise be of interest. These obstacles pose significant barriers to the vital relationship between research and development.

6. Incentives for innovators: intellectual property and prizes

Innovators rarely capture most of the benefits of their innovations: the first businesses to develop computers with graphical user interfaces, jet aeroplanes or semiconductors were not the ones who got rich from them. But it is in society's interests that innovators keep innovating. The system of intellectual property (IP) rights — patents, copyrights and trademarks — is society's attempt to resolve this tension. As intangible assets like research and brands become ever more important to the economy, so does the effectiveness of the IP regime. But there is growing concern it is becoming less, not more effective. The copyright rules are in many ways hindering, not supporting, innovation. Industries like mobile phone design are beset with 'patent thickets', in which companies use IP to obstruct their competitors' own products. There are strong grounds for IP reform, for example, making it harder to patent certain inventions, such as generic features of IT hardware.

We should also make more use of a long-established complement to IP rights that is currently going through something of a renaissance: challenge prizes. Government should set aside a modest fund to establish a few large challenge prizes to address tough but important technical issues.

Background

Intellectual property laws exist to let people and businesses profit from their creations and inventions by giving them, for a fixed period, a monopoly over their new ideas. As more and more of the investments businesses make are in the form of ideas or 'intangibles', good IP law becomes more important.

But all is not well with our intellectual property regime. In particular, it is struggling to cope with the dilemmas of new technologies and business models, and is in need of reform. This is true of both copyrights and patents.

First, digitisation is radically reducing the cost of producing and distributing the kind of information that is regulated by the IP regime, especially copyright. We are, as a society, producing much more content, from web pages to games to music; and the internet has made it easier to share, but also to copy it.

Second, in many areas, the advent of new technologies like search, analytics, and social networks is making it harder to draw clear boundaries around aspects of intellectual property. Information is being generated, shared and recombined at ever accelerating rates.¹⁷⁷ These technologies are based on discovering, combining and distributing information. They give consumers and businesses new opportunities to exercise their creativity. But innovations from music mash-ups to the Google Books project raise questions about where one person's IP ends and another's begins.

Ian Hargreaves's 2011 Review of Intellectual Property argued compellingly that the IP regime, and in particular copyright, has failed to keep up with all this change.¹⁷⁸ As a result it has become a bottleneck for the development of innovative business models. It creates uncertainty about the legality of new ideas, and raises the costs of doing business in IP markets.

We need urgently to adapt IP law and administration so that they protect existing rights owners, while at the same time providing a supportive framework for innovations that reap the full benefits of new technologies, especially digitisation.

This is particularly urgent for the UK, given the importance for our economy of sectors that use intangible inputs and generate informational output. The creative industries — including sectors such as video games, music, film, software development or publishing — are an important example of such industries. And economically important distribution technologies, such as social networks and digital platforms, also depend on the framework set out by copyright.¹⁷⁹

Policymakers have to date been unduly cautious about adapting copyright to the digital age, and failed to balance the needs and interests of incumbents with those of new competitors and consumers.¹⁸⁰ This may help explain why, in spite of their creative excellence, when it comes to innovating in online, mobile and digital markets the UK has been behind competitors in countries where the legal framework is more supportive. Perversely, the copyright quagmire has made illicit sources of content such as peer-to-peer sharing of illegal copies more attractive to many.

The system for regulating patents also has its problems. Granting patents — long-term monopolies — to innovators yields clear economic benefits in industries like pharmaceuticals, where development processes are very long and extremely expensive. Discovering and trialling a new drug now takes around ten years and costs an average of \$550 million.¹⁸¹ Without patents, it is questionable whether businesses would invest in the lengthy process of drug discovery at all. It also makes sense in fields where innovation is, as IP experts say, ‘non-sequential’, that is, when individual innovations are separate from one another.

By contrast, in some other fields, innovations are cheaper to develop and are quickly obsolete or subsumed into other innovations. In these fields (examples of which include software and telecoms), there is less evidence that patenting supports innovation. It is notable that computing and telecoms are two fields where many more patents are granted now than ten or 20 years ago.¹⁸²

This multiplication of patents brings with it other problems. Especially in the US, it means that patents are not always high-value, nor are they well scrutinised by patent offices. And it leads to so-called ‘patent thickets’, which would-be innovators must hack their way through (usually with law-suits or pay-offs) to be able to develop new smartphones, computers or routers.

Genuine innovators are held to ransom by ‘patent trolls’ who buy up portfolios of interesting IP and threaten to sue those who they argue are making unlicensed use of it. The net result is that an institution designed to encourage innovation actually holds it back. As US judge and legal theorist Richard Posner recently argued, in IT-based industries where product cycles last months or even weeks, the disbenefits of unrestrained patenting often exceed their benefits.¹⁸³

Amid the problems of our IP system, the UK is only just beginning to consider **other approaches** to rewarding innovators. One particularly attractive way of doing this is through the use of challenge prizes. These are of course a very old idea: prizes led to the development of the chronometer in the eighteenth century, and canned food, celluloid and

military submarines in the nineteenth century. They are seeing a renaissance in the twenty-first century, most famously in the form of the X-Prizes.

In an era in which the value of crowdsourced and user-led innovations is increasingly recognised in both private and public sectors, and when internet and social platforms offer unprecedented opportunities for collaboration, a new landscape of challenge prizes is emerging.

The US has particularly embraced the use of challenge prizes. The \$10m Ansari X-Prize for private space flight (awarded in 2004) broke new ground in modern challenge prizes, and the X-Prize Foundation now runs large scale prizes in other fields. DARPA has successfully applied the concept to focus on driverless vehicle technology. NASA routinely uses challenge prizes to aid technology development. The US government has recently supported and promoted the use of challenge prizes by issuing a government-wide memorandum in 2010,¹⁸⁴ followed by legislation¹⁸⁵ and by creating challenge.gov in 2011, which has already hosted over 150 US challenges from across federal agencies. More recently the White House Office of Science and Technology policy has worked with Nasa to set up a Center of Excellence for Collaborative Innovation, focusing on challenge prizes.

A number of private businesses and initiatives are helping to take prizes into the mainstream. InnoCentive has used a challenge model to bring millions of minds to bear on over a thousand difficult business and research problems, from finding biomarkers for Motor Neurone

Disease to developing cheap forms of solar-powered light for the developing world. Kaggle uses prizes to encourage data scientists around the world to design algorithms to tackle problems ranging from identifying patients likely to be admitted to hospital to working out which posts blog readers will like the most. TopCoder uses prizes to get programmers from around the world to solve software problems: a recent challenge involved optimising how NASA packed its first aid kits for astronauts. Nesta's Centre for Challenge Prizes, established in 2012 in partnership with the Department for Business, Innovation and Skills, is aiming to grow the market for prizes in the UK among government, businesses and not-for-profits.

Some progress has been made already. The UK has seen several larger-scale prizes in recent years, such as the Scotland-based Saltire £10 million prize for tidal energy advances and Nesta's 2007-09 £1 million Big Green Challenge, a challenge prize to encourage grass-roots groups to reduce their community's carbon emissions. Late 2010 saw the establishment of NHS Challenges, set up to run challenge prizes for the NHS. Organisations such as the Technology Strategy Board, Design Council and 100% Open use challenge-based programmes sharing many of the features of challenge prizes.



IMAGE COURTESY OF THE X-PRIZE FOUNDATION

Ansari X-Prize winner Space Ship One

Experience and research¹⁸⁶ from a range of sources shows that challenge prizes can:

- Attract new innovators to meet a challenge and harness fresh thinking.
- Focus attention and effort on challenges that have been neglected, or that have proved difficult to solve through mainstream research efforts.
- Capture public imagination and generate widespread interest in a new field of endeavour.
- Foster innovation in a wide range of different sectors. Prizes have focused on traditional technological challenges like spaceflight, multifaceted issues like global security, and social issues such as community energy use.
- Encourage dramatic advances by setting ambitious goals.
- Generate commercial activity.
- Limit financial risk by awarding a prize only when the challenge is successfully met.



IMAGE COURTESY OF DARPA PHOTOS

Contender in the 2005 DARPA grand challenge for autonomous ground vehicles

Challenge prizes can be particularly effective when a goal can be defined in concrete terms, and the means for achieving that goal are unknown or too speculative for a traditional research programme, grant programme or procurement.

PROPOSALS

Shrewd re-balancing of the IP regime potentially offers a rich innovation dividend, especially but not only in the creative industries.

Intellectual property law must **better reflect the realities of an economy where media and creative content are for the most part digitised**. The government should follow through on its commitment to implement the recommendations of the Hargreaves Review in full, including reforming the patent and copyright system to limit its scope to where it will do the best job in encouraging innovation.

As argued by Hargreaves, the Government should adopt a **more open approach to IP** in a number of areas beyond the traditional heartland of the creative industries (media and entertainment). Examples include the regulation of data; data and text mining; mining and analysis of rich media; new 'long tail' markets; issues of regulation and competition, and

institutional fitness for purpose. At the same time, it should resist (both in the UK and the EU) the tendency of patents to be granted for increasingly inappropriate general or short-lived inventions.

The Government should lead international efforts to cut backlogs and manage the boom in international patent applications, and resist (both in the UK and the EU) the tendency of patents to be granted for increasingly inappropriate general or short-lived inventions.

The UK should also use **challenge prizes** as a means of encouraging innovation. Nesta has already worked with government to establish the Centre for Challenge Prizes to spread best practice and encourage the use of prizes in business, public administration, and civil society in the UK.

The Government could make use of challenge prizes by establishing a small number of high-profile, high-stakes prizes related to societally important technological challenges. Examples include the development of ultra-low-energy transport systems or treatments for infectious diseases in developing countries. The UK's leading researchers, universities, and high-tech businesses should be tasked with determining the subject matter of the prizes. (Following the example of the X-Prize Foundation, that is, funding not the prize but an insurance contract against the challenge being achieved, means that several £10 million prizes could be financed for a £10 million total investment — even more if private co-sponsors can be found.) Large, well publicised prizes like these can play two roles: they encourage innovation on the part of engineers and businesses, and they also have the potential, through promotion in the media and in schools and clubs, to inspire the next generation of British innovators.

7. Making innovation flourish throughout the UK

The difference in output between different parts of the UK is one of the long-standing issues of the British political economy. It matters because innovation is often place-based: allowing many parts of the country to benefit from many fewer innovative and productive businesses is bad not just for the areas themselves but for the overall productivity of the UK. It is unrealistic to expect any one measure to solve a problem that has been around in one form or another for centuries, or to try to create clusters out of thin air.

As with so much else in the UK, some devolution of power is a necessary condition for smarter local and regional strategies. The work of the Manchester Innovation Investment Fund provides valuable lessons on how this can be done. The devolved administrations of Scotland, Wales and Northern Ireland are all developing distinct strategies, and cover populations of a scale comparable to some of the most successful innovative nations. They are using their smaller scale to be more agile in making decisions, and more strategic in making the most of opportunities.

Big public sector institutions (from NHS Trusts to processing centres) often dominate local economies. But they have not traditionally seen themselves as engines of economic growth, or of innovation.

Universities in particular now need to move to a new generation of tools for accelerating high quality start-ups (through incubator programmes run by entrepreneurs, like Wales's Alacrity Foundation), supporting high-growth businesses, and working closely with foreign investors.

Background

When it comes to economic output, the UK is one of the most regionally unequal developed countries. In the OECD, the only countries with comparable differences in GDP per person by region are Turkey and Romania. The largest regional differences are in Turkey, where there is a factor of 4.9 between the highest and lowest values. In the case of the United Kingdom and Romania the figures are 4.8 and 3.9 respectively.¹⁸⁷

It is important to be clear about why this is a problem. Regional inequality is not the starkest inequality in the UK — the gaps between the rich and the poor in the UK, or between rich and poor areas in a region like London are greater than the gaps between regions. But it matters to our ability to innovate. The potential to innovate is spread much more widely than actual innovation, because innovation depends so much on supportive conditions that make it possible to create, develop and grow ideas. Those conditions are highly concentrated in particular places that achieve the right combination of connections, finance and culture. It follows that if we can encourage effective innovation systems in more of the UK, the economy will grow more overall.

There is strong evidence that the gaps between regions relate to their differing ability to innovate and to adopt innovations from elsewhere to be productive. The UK Competitiveness Index shows that the south east of England leads other UK regions on a whole range of innovation-related indicators, including numbers of business start-

up numbers, the proportion of knowledge-based businesses and the proportion of the workforce with advanced skills.

There are of course impressive innovative clusters outside the south-east: creative industries clusters in Manchester, Edinburgh, Bristol and beyond;¹⁸⁸ life sciences in Edinburgh; biotechnology and video games in Dundee; pharmaceuticals in the north-east; and semiconductor design around Bristol and Bath are just a few examples. But in many parts of the country, innovative businesses and the systems that support them are thin on the ground.

This is of course not a new problem. The North-South divide was a burning political issue in the 1980s. The Wilson Government's 1965 National Plan stressed the need to encourage economic growth 'beyond the south east and Midlands'. Decades of pushing public sector administrative jobs out of London has if anything exacerbated this problem, partly because many of these jobs are in themselves relatively uninnovative and partly because they are often relatively highly paid, making it harder for local small businesses to grow. But there is nothing inevitable about any particular economic geography: in the nineteenth century much of the most dynamic economic growth happened outside the south of England.

Although the problem is not new, it may be getting worse. The abolition of the Regional Development Agencies is likely to reduce the amount of investment going into innovation in most English regions. Between 2008 and 2011 the RDAs invested or planned to invest £459 million in innovation and technology programmes in England, a sum unlikely to be matched by replacement funding available through



IMAGE COURTESY OF EDINBURGH SCIENCE TRIANGLE

Research in the Edinburgh BioQuarter, a £600m life sciences research and commercialisation development

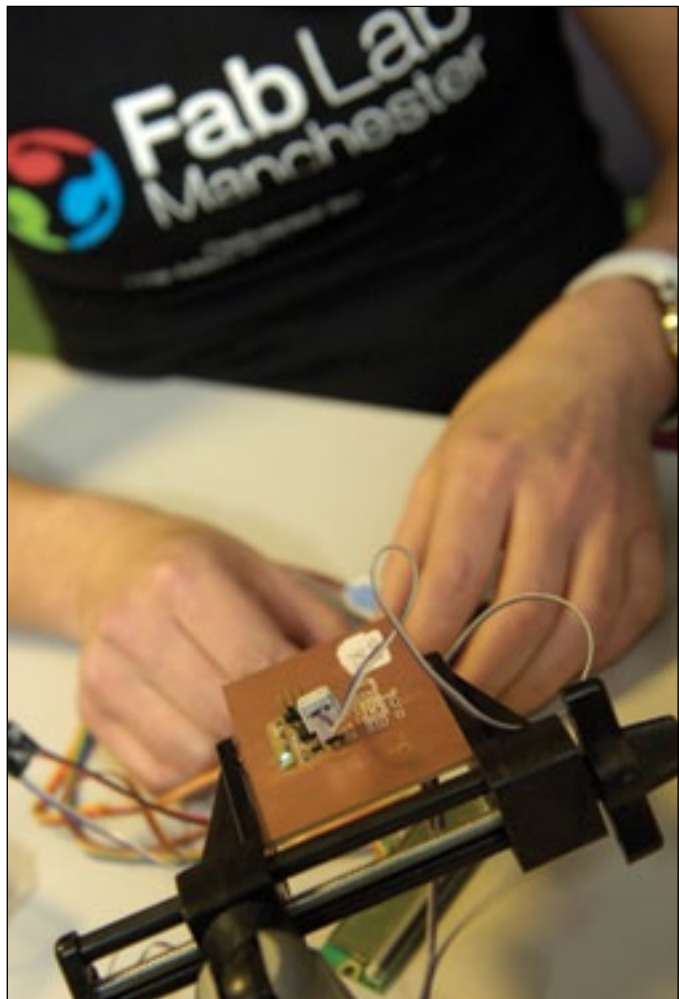


IMAGE COURTESY OF THE MANUFACTURING INSTITUTE

Manchester's Fab Lab helps inventors turn concepts into reality

the TSB, the Regional Growth Fund or otherwise (Wales, Scotland and Northern Ireland have other sources of support). Experience so far with Local Enterprise Partnerships is mixed: some appear to be highly effective at understanding and acting on local needs, others less so, and experience suggests that it takes many years for new agencies to move up the learning curve and become effective. (The UK has a particular tendency to invent and abolish institutions. Other countries tend to keep their institutions — look for example at the longevity of bodies like DARPA in the US or Sitra in Finland — but with great adaptability within them. This keeps their management focused on outcomes and value rather than shuffling organograms).

Information is also a potential barrier. In many regions of Europe, there is a drive towards so-called ‘smart specialisation’, investing in areas of unique local strength. However, trying to do this without deep insight into local economies can be difficult — resulting in absurd situations like that seen some years ago when eight of the UK’s nine RDAs claimed to be life science centres of excellence or the 2010 survey in which 39 out of 56 cities told Centre for Cities researchers that the creative industries to be one of their key advantages, while too much self-designated regional expertise was not globally competitive. Many LEPs report not having adequate business information to make these kind of judgements. Japan offers an interesting model in this respect: there, considerably more data are gathered on regional economic activities, where in the country imports end up and where exports come from and how regional workforces align with businesses. This makes it easier to understand the strengths and weaknesses of local economies.

There are however some opportunities. One bright spot in this story is the UK’s continuing ability to attract Foreign Direct Investment (FDI). FDI has played a valuable role in bringing innovative businesses and practices to the UK, especially in regions outside the south east. The example of Ireland, where the development agency Forfas works hard to weave local businesses into the supply chains of inward investors, suggests that there are more opportunities here. Forthcoming research from Nesta will identify the impact that inward investors have on the innovation capabilities of UK firms.

Another potential opportunity stems, paradoxically, from the importance of the public sector in many of the UK’s nations and regions. On the whole, the weakness of private firms and the strength of public employers has held back productivity growth in much of the UK. But perhaps there is a silver lining. There are examples around the UK of public bodies that have helped encourage innovation in their local areas: one is the role of Newcastle University, which has styled itself a new ‘civic university’ and embraced wide-ranging connections with its local business community and civil society.¹⁸⁹ Another is the role of Ninewells Hospital and Dundee University in helping give rise to Dundee’s thriving biotechnology cluster.¹⁹⁰

PROPOSALS

A ‘wicked issue’ like this is unlikely to be solved with a single policy. However, a range of proposals may help encourage the formation of more vibrant innovation systems across the UK.

Supporting clusters

Policymakers should support innovation excellence where it exists. Making it easier to build housing and transport links for thriving clusters outside the south east is essential.

And local economic partnerships should prioritise innovation when setting up their plans for these thriving areas. One example is Manchester's Innovation Investment Fund which invested in a Fab Lab — a workshop allowing small businesses and designers to prototype and manufacture real products as well as a ground breaking voucher scheme to encourage collaboration between innovative businesses.

The power of public institutions

In areas where the systems that support innovation are weak, major public institutions need to recognise the power they have to improve their local economy, and step up to this role. This may involve building stronger links with emerging local businesses, taking on apprentices, or procuring innovative products locally using schemes like SBRI. Equally, it may involve playing a coordinating role in wider economic partnerships such as LEPs. Sceptics may doubt the ability of large public organisations to foster innovation at scale. But as long as they are dominant employers in a town or local area, they need to recognise their role.

We should do all that we can to encourage entrepreneurship to thrive. The work of charities like the Alacrity Foundation in Wales, established by the tech entrepreneur Sir Terry Matthews, which helps young graduates to become entrepreneurs, by connecting them to skilled mentors and backing them financially, is the kind of thing that many parts of Britain need.

Encourage foreign investment

We should make the most of inward investment and FDI. Irish-style supplier development programmes embedded in the regions directly linking small businesses to inward investors would help spread the benefits of big foreign investments throughout the local economy. Wherever possible these should build upon existing schemes to avoid the loss of corporate knowledge and experience. The LEPs are the obvious vehicle to deliver this but there are other possible local channels, including Chambers of Commerce, who, with some funding support, could bring together businesses interested in supplying inward investors and help them meet cost/quality requirements.

Cities as living labs

Cities and regions should be more deliberately mobilised as laboratories for the future. We need real-life experiments and living laboratories in new models of transport; energy; care; exercise, and towns and cities should be encouraged to build up their capability to innovate systemically, linking public agencies, business and the public. Some examples may be technology intensive — like testing out the next generation of fuel cells in social housing; others will not be — like experimenting with methods to sharply increase exercise levels across the population. But the ability to act like a laboratory may turn out to be a comparative strength of places that are relatively weak in terms of traditional R&D capacity. The Future Cities Catapult centre should work to support cities choosing to make this leap.

Better business data

Finally, technology may be able to help LEPs make smart investment decisions by providing better data on local business performance and strength. Recreating the quality of business data available in Japan is likely to be expensive and bureaucratic. But increasingly, services that crawl web data, or analyse company accounts databases, are able to provide sophisticated business analytics. A terrific example of what is possible is the Cambridge Cluster Map, published in September 2012, which combines a wide range

of data sets to provide a dynamic map of the Cambridge economy with a focus on its tech sector and links within it. A small investment by BIS or DCLG in these kinds of services could give a valuable set of tools to LEPs to make more evidence-based decisions about where to best use their limited resources; it is an area of future focus for Nesta too.

8. Strengthening public and social innovation

Public services represent 22 per cent of measured GDP. Civil society is not just socially important — it also represents a significant share of the economy in the form of charities, social enterprises, and mutuals. But social innovation and innovation in public services are often neglected by innovation policy. In the past innovation policy has emphasised hardware rather than services, commercial impact rather than social impact, and business rather than civil society. But this is beginning to change, with many examples of more systematic innovation in public services and civil society across the world.

The UK has many strengths in public and social innovation.¹⁹¹ But it has consistently failed to link up disparate initiatives, or to develop a more effective system of innovation in these fields, comparable to the systems that have grown up around everything from computing to medicine.

The pressures to drive up public sector productivity should be used to put this right: with more systematic experiments; more systematic evaluation of what works; and more systematic mechanisms to scale up the approaches that deliver the best results.

Background

Much discussion of innovation and economic growth focuses on private businesses and new technologies. The government gets a look in only to the extent that it influences the business environment or funds research. But this misses something significant. Innovation in public services and civil society matters too, for five reasons.

First, they are a big part of the economy: public services represent around 22 per cent of measured GDP in the UK. The voluntary sector is also substantial, whether measured as a share of GDP (perhaps 5–7 per cent) or as a share of time.¹⁹² So whether or not they are innovative and productive has a direct impact on national prosperity.

Second, they tackle societal problems that, if left unaddressed, will make our lives worse and the country poorer. Examples include the costs of caring for an ageing population,¹⁹³ preventing or dealing with climate change,¹⁹⁴ or managing long-term illness.¹⁹⁵

Third, they play an important role in allowing for future economic growth. Nineteenth-century social innovations like cooperatives, building societies, compulsory education and corporations helped innovation to flourish in the Industrial Revolution.¹⁹⁶ Modern day movements like crowdfunding and ‘collaborative consumption’ may play a similar role in years to come.

Fourth, some of the sectors most likely to grow as a share of GDP over the next few decades are ones where public and civic organisations play big roles — including health, care and education.

Finally, the public sector now faces fiscal pressures more intense than at any time in living memory. The jury is still out on whether these will help or hinder innovation — and there are signs that in the short term the effects have been negative, with leaders ‘frozen in

the headlights'. The risk is that cuts without innovation will ultimately lead to stagnation. This makes it all the more important that political leaders, as well as officials, grasp the nettle on innovation (Nesta's recent publication 'The Art of Exit', for example, shows how decommissioning has been used to transform services for the better).

Systematic investment in innovation in public services and social innovation is therefore a critical part of any plan for economic growth.

There are many good examples of public and social innovation around the UK, from dynamic not-for-profits to creative new initiatives led by public service workers. People who assume the public sector cannot innovate are forgetting that the NHS pioneered heart transplants, genetic testing and in-vitro fertilisation,¹⁹⁷ and that telephony was pioneered by the Post Office.¹⁹⁸ Civil society also has its fair share of innovative breakthroughs, from the establishment of the hospice movement to the creation of the Open University.

Many people want to explore new ways of organising life, economic activity and society, from the Maker Movement to the Occupy Movement and from Mondragon to microcredit. Transition towns and timebanks, carers networks and community bonds are all symptoms of grassroots creativity in response to the crisis. At a time of significant technological and economic change, and dissatisfaction with the very visible failures of traditional economic institutions, this should come as no surprise. Last year, a survey of the social enterprise sector found that 14 per cent of all social enterprises are start-ups less than two years old — more than three times the proportion of start-ups among mainstream businesses. The data also shows that the social enterprise sector is outstripping SMEs in growth, confidence and innovation.¹⁹⁹

Looking ahead, the UK's future prosperity will come not just from the dynamism of its economy but also from its ability to nurture, develop and test the most interesting social innovations that these diverse movements devise, and adopt the best of them.

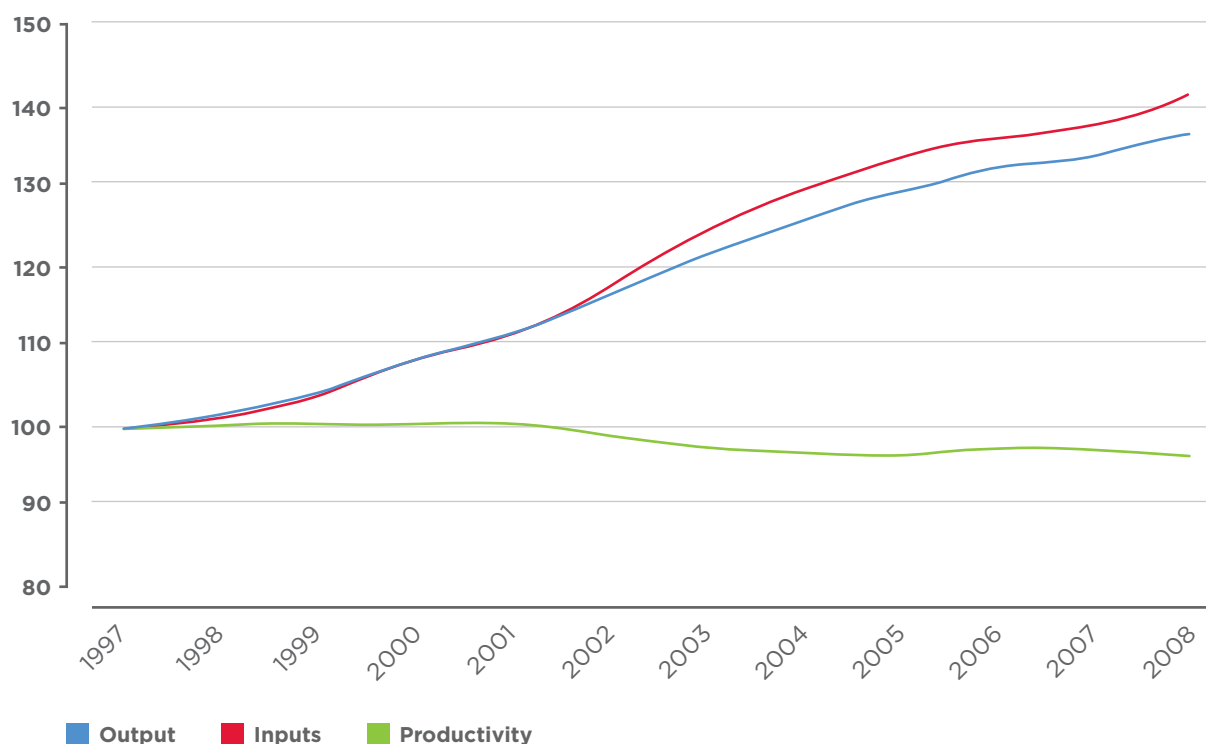
But the overall picture is one of a system that is not always welcoming to innovation and is making only slow progress in tackling the big social challenges, from ageing and youth unemployment to crime and drugs.

Indeed, public service productivity has not increased over the past decade (see Figure 19), despite significant investment and a passion for public service reform on the part of government. The causes of this are highly contested,²⁰⁰ but it does not suggest a period of wildly successful, disciplined innovation.



IMAGE COURTESY OF DANONE COMMUNITIES

Beneficiaries of the Grameen microcredit partnership with French yoghurt manufacturer Danone in Bangladesh.

Figure 19: Total public service output, input and productivity estimates, UK 1997–2008

Source: Office for National Statistics

This issue goes much deeper than the stark numbers of public sector productivity.

There is a growing recognition that the way we deliver many public services is unsustainable. A healthcare system that is still dominated by acute hospitals; a social care system whose budgets will be overwhelmed by the cost of caring for the coming wave of older people; a criminal justice system that often neither rehabilitates the criminal nor protects the victim: all of these things suggest that radical change is needed. Yet the barriers to innovation are strong: inertia; public attachment to familiar models; risk aversion in politics and civil service culture; and money locked into existing, failing approaches.

There have been many initiatives, funds and programmes over the years. But these have come and gone with very little serious institutional commitment, little accumulated learning and none of the build-up of skills and institutions that lies behind the long-term success of systems that create new technologies and new medical procedures.

The result is that too many of our systems don't connect well, don't anticipate, and don't apply best practice. Making the UK a better place for social and public service innovators requires us to create a system that supports effective innovation.

We would expect any innovative organisation to have several characteristics:

Knowledge and evidence. A clear idea of the most urgent needs for innovation, awareness of what works elsewhere in the world or within the organisation, and effective ways of sorting the really successful new innovations from the rest.

Experimentation and prototyping. The willingness to try out new approaches.

Openness. The willingness to help others to innovate, for example giving citizens platforms and data to improve services themselves.

Scaling up. The ability to allocate resources to implement ideas that work or scale them up (and to stop what doesn't work).²⁰¹

Skills. Strength in depth in the practical skills of taking ideas all the way from inception to impact at scale.

None of these conditions is widespread in mainstream public services. Although there is no shortage of good ideas, public sector organisations find it hard to make space for them (and often have little incentive to do so),²⁰² and in civil society they often lack the support to turn into robust, practical projects. When it comes to assessing which innovations work, the quality of evidence for the effectiveness of new public innovations is often very weak or unavailable, meaning that we simply do not know whether new ideas outperform old ones.²⁰³ Scaling is a tricky business — often great innovations stay small-scale for too long; occasionally untested ideas are rolled out nationally and turn out to be ineffective.²⁰⁴

Getting this right will also involve building on existing strengths, as well as creating new ones. We have many fields with strong innovation skills — from the creative industries to science and advanced manufacturing. But little has been done to adapt and spread these skills into the public sector. Initiatives like the NHS Institute for Innovation, or the Department for Education's Innovation Unit, have either been subject to endless restructuring, or simply squeezed out. There is not a single example of the kind of sustained commitment that made institutions like DARPA so successful.

Yet the successes of recent decades show how much can be achieved by creative partnerships between government and others. The London congestion charging scheme and cycle hire scheme are both good examples; the steady experimentation around welfare to work programmes under successive governments is another that has linked creative funding and policy design with innovation on the part of both for-profit and not-for-profit providers.

That the UK is now seen as a world leader in social investment is also the result of partnership. The world's first Social Impact Bond happened because of a creative gamble by a government department, and a creative collaboration between foundations and finance — and it's now being emulated in the US, Canada and Australia. Big Society Capital now offers the world's largest pool of wholesale social finance, again the result of many years of collaboration between finance, civil society and government.

Strengths in open data are likewise the results of creative relationships that straddle the boundaries of the public sector. The government, together with charities like MySociety and Rewired State, have made the UK into a hotspot of open data.

There is also now a growing network of practitioners in public and social innovation worldwide who are sharing methods and skills — including organisations like Mindlab in Denmark, Sitra in Finland, PS21 in Singapore, MaRS in Canada, TACSI in Australia, as well as the various programmes of Mayor Bloomberg in New York or Mayor Won-Soon Park in Seoul.

All of this offers us a strong foundation on which to build. But successive governments have been surprisingly piecemeal and unsystematic, usually offering only rhetoric and very small-scale initiatives. There has certainly been nothing comparable to the ambitious programmes that so transformed technological innovation during the 20th century. If we want serious results, that now needs to change.

PROPOSALS

Innovation is bound to be very different in fields as varied as waste management, prisons, policing, schools, healthcare and tax collection. Here we focus on some of the generic priorities that can turn the disparate efforts of enthusiastic innovators into more systematic long-term impact.

Knowledge and evidence

The first priority is to help practitioners and policymakers know what is already known: to learn from promising ideas as well as proven ones. The internet offers enormous potential for sharing information about good ideas, but this potential has not yet been realised in the field of social and public service innovation. Nesta, working with organisations like the Young Foundation and OO:/ has supported several initiatives to spread knowledge of effective social innovations through projects like the Open Book of Social innovation, the Compendium for the Civic Economy and the Social Innovation eXchange (SIX).

But within public services, surprisingly little systematic effort has gone into scanning for promising ideas and connecting these to practitioners, even though this has always played a crucial role in technological innovation. This doesn't have to be a role for government, but without some systematic scanning and mapping in fields such as eldercare or childcare, social finance and vocational training, wheels are bound to be reinvented and mistakes unnecessarily repeated. Where no one is playing this role, government should ensure that the gap is filled.

This scanning of emerging ideas needs to be matched by an equally vigorous mapping of ideas that have matured and can point to strong evidence of impact. As writers like Ben Goldacre and Mark Henderson have observed, government innovations are all too often untested and unpiloted. Poorly evidenced innovations are more likely to fail, and in the long run weaken support for those innovations that do work, meaning that public services are worse and costlier than they could have been.

To address this, we call on the Government to work with research councils, public bodies and social innovators to build a stronger infrastructure of institutions dedicated to orchestrating evidence about what works, and ensuring that it reaches decision-makers and meets their needs. Along with the ESRC and Big Lottery Fund, Nesta has established the Alliance for Useful Evidence to promote this idea. We have also advocated what has been described in shorthand as a **'NICE for Social Policy'** or **'What Works' centres**. In practice we envisage a network of sector-specific centres supported by a national centre responsible for standards, and innovation in new methods of evidence.²⁰⁵ These centres must learn from earlier, failed attempts to provide evidence for public policymakers which showed that it's not enough to supply more evidence. Just as much attention needs to be paid to how evidence is demanded and used. This is why we emphasise useful evidence: reliable information about what works that meets the needs of commissioners and service providers. Fortunately there are many good examples within specific public services, from

NHS Evidence and the Education Endowment Fund to Sweden's quality registries and competence centres in health, which embed evidence and learning into public bodies.

We also argue that the Government should commit to routinely publishing the evidence it has used to make new public spending decisions — in particular to approve new programmes or continue old ones. This could take the form of a **'Red Book for Evidence'**, published at the same time as the Budget and alongside the Budget appendices, which shows the estimated cost of each new policy. This would not rule out the Government trying new policies for which the evidence is uncertain (Plan I is a strong supporter of experiment — and indeed many of our own recommendations are experimental). In many areas of policy there simply isn't enough evidence. But a Red Book would encourage much greater clarity about what lies behind important policy decisions.

The other gap we see is for shared metrics and impact assessment tools. It is highly unlikely that anyone will come up with universal measures of social value or social impact. But much could be done to develop more rigorous measures of social impact field by field, comparing for example projects around homelessness, families, reoffending or drugs, and the ways in which these gather together both costs and measures of impact. Again this is territory where the web is a hugely useful tool.

Experimentation and prototyping

At its worst, public sector innovation is famine or feast: either no innovation at all due to the pressures of day-to-day delivery, or innovation with no rules that fails to get traction in the system. The best innovation is not like this: it is disciplined, and draws on methodologies, whether from within professions or from ideas such as design thinking or open innovation.

Nesta has worked with many parts of the public sector to test out different approaches to ideation and prototyping — widening the menu of options that can then be tried out. These can now be applied in many areas of public policy and public service — drawing also on the experience of the many labs, design teams and incubators across the world.

The key to making these work is clarity about needs; openness to ideas and approaches; and the ability to put ideas into practice on a small scale first to learn.

These are needed most in the fields where systems face the deepest crises. They include ones like social care where costs are already very high and growing, as well as sectors such as parks and libraries where it's likely that funding will be severely cut in the years ahead.

Nesta's work with innovators in local government, the NHS and civil society has shown how much public services can benefit from more disciplined methods of innovation. The Creative Councils programme has been built on for the Bloomberg Philanthropy Mayor's Challenge in the US; People Powered Health has been recognised as a pioneer of coproduction in healthcare; while the Innovation in Giving programme is at the forefront of new tools for mobilising money and time in civil society.²⁰⁶ The methods developed for generating ideas and prototyping in these programmes now need to be used more widely. The sums involved are relatively small: but they have the potential to unlock radically more effective ways of delivering services. Anyone in a leadership position in public services should be able to say how they are developing the service models of the future, just as any leader in an innovative business would expect to be held to account not just for current performance but also for their pipeline of new products and services.

Openness

Innovation isn't just about experts or professionals. Government needs to give people beyond the public sector the freedoms and platforms to innovate. A number of steps have been taken in this direction recently. The US Federal Government launched Challenge.gov and many others have experimented with crowd-sourcing ideas.

Much has been learned about what does and doesn't work with platforms of this kind. The results are much more complex than earlier rhetoric about the 'wisdom of crowds' suggested. But there is now no doubt that many areas of decision making, and creativity, can benefit from much greater public engagement, some of it online and some through face-to-face events. All government departments and agencies should at the very least be aware of the options.

There is also much to be done around data. In the UK there have been moves to open up data, from the Open Public Services White Paper to the establishment of the Open Data Institute. Some of the most valuable public data sets have been opened up, from transport timetables to Ordnance Survey's OS OpenData.

We recommend that this approach be taken further. **Open data should be the default** for public services, unless there is a clear reason for secrecy.²⁰⁷ An example of the battles that remain to be fought is that over medical records. Anonymised health records offer an enormous resource for improving medical science and the working of the NHS. Healthcare providers in Germany and the US already use health data very effectively to improve services and reduce costs, and parts of the NHS have led the world in mapping population risks, and using predictive modelling to guide practitioners. But currently medical records are difficult for researchers to access. The NHS should change its default settings in this respect, so that anonymised health records can be used by researchers unless the patient actively chooses to opt out.

Scaling up

For public and social innovation to be systems, they need to be able to scale or grow models that are clearly working. At present scaling is fairly random, partly because of the lack of strong evidence and partly because of a political culture that often picks on ideas more for their appeal than their impact. Resources do not automatically flow to approaches that work best.

Institutions like NICE are moves in the right direction and have shown the strong evidence behind some clinical interventions, and some public health ones. In every field there are now some reasonably well-evidenced approaches that could be spread more widely. One well-known example is Family-Nurse Partnerships, a programme for vulnerable first-time mothers, which has benefited from huge investment in evaluation over several decades, has been shown to improve health outcomes significantly and return £3 to £5 for every pound spent on it,²⁰⁸ but which is still a relative rarity in the UK.

The creation of What Works centres should help the spread of proven models. For civil society, the advent of the Big Society Bank, and finance to support social enterprises and charities bidding for pay-by-results contracts, should also reward the scaling of successful ideas.

But more needs to be done, and in particular to address cross-cutting issues. The next spending review should therefore commit to setting up a substantial fund (at least **£500 million to £1bn**) to support the adoption of evidence-based programmes to tackle cross-

cutting public services challenges. The money would come from a levy on all public service departments, and would be available to local delivery bodies, such as NHS Foundation Trusts or Local Authorities (or partnerships between them) by a competitive process administered by the Cabinet Office. Its aim would be to help public sector organisations pay for projects with strong evidence of success on dealing with high priority social issues where both the costs and benefits cut across organisational boundaries. Examples include troubled families, long-term health conditions, ‘dual diagnosis’, or providing services for an ageing population. There should be a requirement for co-investment from more than one public sector agency, as well as for rigorous evaluation, and a commitment to developing longer term funding arrangements that better combine public funds and reflect the balance of benefits achieved. Such a fund should be developed in parallel with similar innovations, including payment by results and social impact bonds, which are also attempting to align incentives to tackle complex problems.

The purpose would in part be to direct money to fields of greatest possible return. But just as important will be the development of more effective methods: better skills at assessing projects and developing them; and better tools for analysing risk and returns.

This should be seen as part of a package. At present the best-evidenced programmes are not necessarily the best ones: they may just have been lucky in gaining funding from wealthy (often US-based) foundations. That’s why a more systematic approach to evidence and scaling has to go hand in hand with more energetic innovation, experiment and development of ideas that are promising but not yet proven.

Skills and leadership

The final priorities are skills and leadership. Innovation skills are now highly developed in much of business, across science, and in fields such as technology transfer. By contrast very little attention has been paid to skills in public and social innovation — which is why even the most creative leaders struggle to turn disparate initiatives into something more systematic.

Nesta has been working with many partners to address this, making practical skills, courses and case studies widely available over the internet and through classes. We see this as a key priority for the next few years — and are focusing on the very practical skills of how to design new services, how to finance them, how to evaluate and how to scale.

As in business, however, strength in depth in skills also needs to be matched by leadership. We need public service leaders willing to champion innovation and innovators; to celebrate successes but also recognise that risk is also bound to involve failure; and to make innovation as much part of the DNA of public service as impartiality and financial probity.

9. Getting smart about evidence and data for innovation policy

Measurement matters. Evidence matters. Since much innovation policy is experimental in nature, policymakers and voters need good evidence based on sound data to know if it is working. Otherwise they risk wasting money on bad policies and failing to make the most of good ones.

There are two aspects to this. The first is economic data on innovation. Governments track innovation data with interest and base their policies on these metrics. The quality of these data, which until recently relied almost exclusively on narrow indicators like R&D spending and the number of patents granted, is improving. But there is still more to be done if we want innovation statistics that reflect how innovation actually happens. Better metrics may lead in due course to better policies, in particular ones that reward not just R&D, but other intangible investments that businesses make to turn ideas into reality.

We also need to do a better job of measuring how well innovation policy itself works — too much innovation policy is currently a black box. When government commits to spend taxpayers' money on innovation policies, it should gather data on those who apply and what happens to them, and wherever possible use randomised controlled trials (such as Nesta's Creative Credits trial) or other rigorous techniques to see whether they are really having an effect.

Background

For several years, Nesta has argued that traditional metrics of innovation focus on only a small part of what actually goes on when businesses innovate.²⁰⁹ Countries measure how much they spend on R&D, even though only 11 per cent of innovation investment takes the form of R&D,²¹⁰ or the number of triadic patents granted per head, when many of the most successful innovations are not protected by patents.²¹¹

This is gradually changing. Thanks to the work of a range of organisations, including the OECD,²¹² the EU Innodrive project,²¹³ BIS²¹⁴ and researchers like Imperial's Jonathan Haskel and the Conference Board's Carol Corrado, different ways of measuring innovation are coming to the fore. In particular, measuring business investment in innovation and its effect on economic growth by measuring intangibles has become a widely recognised alternative to crude measures of science and technology spending. (Intangible investment includes a wide range of investments that businesses make to turn an idea into reality, including R&D but also encompassing design, organisation change and new software development among others.) Nesta's Innovation Index, first published in 2009, played an important role in this process, showing the contribution that businesses' innovation investment makes to UK productivity.

However, there is more to be done. Just as the measurement of innovation in its wider sense was being accepted around the world, the resources of the UK's statistical agencies are being cut, threatening their ability to provide the essential data on which credible innovation metrics are based.²¹⁵ (Funding for the Innovation Scoreboard, another long-standing indicator of UK innovative capabilities, has also been eliminated.) Without good metrics, it is more difficult to make good policy.²¹⁶

It is not just innovation performance that we risk mismeasuring. The policies that government puts in place to encourage innovation are also, on the whole, poorly evaluated and tracked.

In other fields of public policy, for example education or foreign aid, we are seeing a movement towards more rigorous evaluation of how effective different policies are. Early pioneers of this movement include Harvard's Ed Lab, MIT's Jameel Poverty Action Lab (J-PAL), John Hattie (now at Melbourne), University College London's Peter John, Southampton's Gerry Stoker, Birmingham's Carole Torgerson and Laura Haynes of the Cabinet Office's Behavioural Insights Team, or France's Fonds d'expérimentation pour la jeunesse.²¹⁷ In some cases, they have used randomised controlled trials (RCTs) to investigate whether policies really worked and if so, under what circumstances. Nesta's Alliance for Useful Evidence is making the case for greater use of good quality evidence in policymaking.

Innovation policy is rarely so well evaluated. Nesta's Creative Credits programme provides a rare example of an innovation intervention backed up with an RCT.²¹⁸ Research led by John Van Reenen into the R&D tax credit and regional business aid programmes takes advantage of natural experiments to show the effectiveness of different policies. But on the whole, evaluation is much more qualitative. In some cases this may be inevitable — very complex, system-wide interventions are difficult to evaluate quantitatively. But too many programmes are currently set up in ways that mean that data on how well they are performing are not gathered.²¹⁹

Innovation policy's evidence drought is a problem for two reasons: firstly, it means that money is likely to be wasted on ineffective policies, while the most effective policies receive less funding than they should. Secondly, it means that, as the Treasury increasingly demands better evidence of how effective policies are before it agrees to fund them,²²⁰ innovation policy may end up underfunded compared to other spending priorities that have done more to build their evidence base. The TSB's SMART award programme is an example of a programme which for several years had something of a Cinderella status, but which was recently scaled up after a review of evidence showed its effectiveness.

What's more, there is something larger at stake. Data science is a field of explosive growth and huge technological potential. But as it grows in its influence, the ability to mislead with bad statistics, to use data for nefarious ends and to draw false conclusions from good information will also grow. By taking data and evidence seriously, the government can both minimise the risk that it falls prey to these problems, and set a good example for others. It's not implausible that in a future world, data scientists would abide by a code of conduct like other professionals or researchers²²¹ — and if so, the government, which has privileged access to vast piles of data and a powerful platform for spreading its message, should be doubly accountable.

PROPOSALS

In the short term, the Office for National Statistics should be **adequately resourced to generate good innovation metrics, in particular measures of intangible assets**. These should be developed as satellite accounts to the National Accounts, and in due course should be incorporated into them fully to reflect the importance of innovation to economic growth.

In the longer term, as this evidence base develops, the government should **consider whether existing tax credits adequately reflect how businesses innovation happens.** The current R&D tax credit subsidises R&D because of its spillover benefits to the wider economy.²²² If, as our understanding of other intangible investments improves, it becomes clear that other types of innovation investment, such as design or innovative training, also have big spillover benefits,²²³ we should consider whether the R&D tax credit should be modified and broadened. (Singapore's Productivity Tax Credit, which encourages R&D, design, and other process improvements, could act as a model for such reform.²²⁴)

The Government should ensure that its policies to promote innovation **gather the data needed for them to be rigorously evaluated,** and that a sensible evaluation plan is baked in from the start of any new policy. The 'gold standard' of the randomised controlled trial may not always be possible or appropriate, but even when it is not, collecting the right data at the outset can enable cheap, credible assessment of whether a policy is working or not.

10. Innovation in jobs and the labour market

With unemployment at over 2.5 million, one of the most urgent requirements of any recovery plan is that it creates jobs. But job creation is not just about increasing economic output, the demand for labour. It also depends on the economy's ability to match people to jobs, and to find new ways to bring people into the workforce — the supply side. This recommendation looks at how innovation in the labour market itself can reduce worklessness.

More systematic innovation in jobs is needed because many parts of the labour market don't work well. Too many public programmes try to connect poorly prepared job-seekers to bad and badly paid jobs, without much success. We call for more experimentation around ideas: to test out tools to help the self-employed take on their first employee (minimising the risk and paperwork involved) or use complementary currencies to boost demand in areas of high unemployment, or shift norms around apprenticeships (such as requiring every £1m of public spending to support at least one apprenticeship). Current examples of innovations include Fusion 21's Employer Pool (which helps turn short-term opportunities into long-term jobs), or tech platforms like Taskrabit that make it easier for small businesses to hire workers. Few issues have as acute a need for innovation. But so far systematic innovation in this field has been neglected. We also argue for much more intensive measurement and assessment of what works so that successful models can be scaled up. So far, the structure and terms of the Work Programme, the government main welfare-to-work scheme have not encouraged much innovation. The DWP's new Innovation Fund should focus on stimulating more radical experiments.

Background

The problem: cyclical and structural unemployment

Most economic policies see increased employment as their result. This is true of Plan I too: innovation leads to economic growth which leads to new jobs. But innovation can also play a more direct role in getting people into work. Innovation in the way the economy matches people to jobs can directly increase employment over and above the benefits of economic growth.

Predictably, unemployment has risen since the recession,²²⁵ though not as much as some feared. More worryingly, it has stayed high, falling slower than in past downturns.²²⁶ The current unemployment rate is over 8 per cent, and long-term unemployment has increased substantially, with the number of long-term JSA claimants now at its highest level. Youth unemployment (including students) is over one million.

This is not just a problem in the short term. There are now fears of a 'lost generation' of young people — shut out of the labour market, increasingly disconnected from work and learning, and 'scarred' throughout their working lives due to the experience of unemployment when young.²²⁷ Moreover, there is evidence that some of these problems had their roots in the years before the financial crisis. The increase in youth unemployment

started in 2004. Between 2004 and 2006/7 there was a substantial growth in the number of young people unemployed and in the number young people not in employment, education or training (NEET).²²⁸ Unskilled men also faced problems: one in two men without qualifications was not in work in 2007;²²⁹ people with disabilities are three times more likely than non-disabled people to exit from work²³⁰, and lone parents twice as likely.²³¹ A further longstanding problem is economic inactivity, rates for which have remained very similar (at around 22 per cent to 23 per cent) over the last 20 years.²³² Shifts in the profile of jobs haven't helped. The labour market has seen increasing wage inequality with a 'hollowing out of the middle' as the labour market has become polarised between high and low earners.²³³

This suggests that in addition to a recession-induced fall in the demand for labour, there is a continuing mis-match of supply and demand. While skills have been rising, the increases have been quite small in comparison with some OECD countries. At the same time, the rise in prevalence in skilled occupations is also relatively small. As a result, neither the supply nor demand for skills are expanding fast enough.²³⁴

Alongside this shortage of supply and demand at the higher skilled level, increases in educational attainment over time have led to rising populations of over-qualified employees with intermediate-skills, providing an excess supply for the shrinking demand for intermediate-skilled jobs. Essentially, this means that there is an excess supply of people with intermediate level or non-specialised qualifications who: are not meeting the demand for skilled jobs; are not required by the shrinking demand for mid-level occupations; and who are over-qualified for low level occupations, for which there is also some demand but excess supply.²³⁵ With these over-qualified people having to take on unskilled jobs, those at the bottom of the ladder (without skills) are being squeezed out. This pattern has been reinforced by a rising use of credentialism among the lowest-level occupations.²³⁶

The role of innovation

The structural aspects of the UK employment problems are a reminder that there are two ways to tackle worklessness: by increasing the demand for labour by growing the economy; and by improving the ability to match people to jobs.

Most of this report concerns the former: and there is no doubt that without economic recovery it will be impossible to create the jobs the UK needs. But here we focus on the latter question, how innovation can improve the job market itself.

EXAMPLES OF INNOVATION IN JOB MARKETS

Tech platforms. There are a range of tech platforms that match people with free time to small jobs, including Task Rabbit, Slivers of Time and Amazon's Mechanical Turk. Their potential is almost certainly underexploited. For example, it has been claimed that many sole traders are put off employing their first employee by the complexity of administering the process. Could banks and other services provide standardised services to reduce the burdens and risks? Could hyper-local media sites match individuals to bits of work in their local community that in total can give them employment that meets their needs? Could IT platforms make it easier for micro-businesses to create jobs?

<http://www.taskrabbit.com>

City Deals. The core cities have estimated that the first wave of deals will create 175,000 jobs over the next 20 years and 37,000 new apprenticeships. Earn Back (Greater Manchester) has a new payment by result model that incentivises a city to invest in growth in return for a share of the national tax take. This could mean creating new delivery vehicles that really pool funding pots to be much more creative. Past attempts have never had this much power and money to do it.
<http://www.dpm.cabinetoffice.gov.uk/resource-library/wave-1-city-deals>

Fusion 21's Employer Pool. Employer Pool links procurement spending to job creation, creating sustainable jobs in local communities by sourcing temporary workers whose skills meet employers' needs and directly employing individuals and stitching packages of work together to create sustainable employment for individuals (e.g. refitting windows in large housing estates — doing one estate gives someone a job for two months; working with all Housing Associations and pooling work of multiple estates gives someone a job for two years).
<http://www.employerpool.co.uk/>

CaliberLink is a one-stop service for Professionals, Managers and Executives (PMEs) set up by the Singapore Workforce Development Agency (WDA) focused on scale, quality and personalisation. It co-locates training providers, careers services and recruitment support in a One-Step Centre, uses distance learning techniques through a Learning Gateway to offer quality training to ensure PMEs stay employable and progress, and has an Employment Exchange to meet the needs of employers and PMEs.
http://www.wda.gov.sg/content/wdaweb/L213-007Announcements/05_Feb_2012_2.html.html

Kidzania (Children's Job Experience Theme Park) in Seoul is a theme park for children aged 3 to 16 to simulate work experience for young people, applying the methods of a theme park to career planning and job readiness. The park originated in Mexico and has spread throughout the world, opening in Korea in 2010.
http://english.visitkorea.or.kr/enu/SI/SI_EN_3_1_1_1.jsp?cid=1220743

The **Belgian service voucher scheme** is a consumer subsidy introduced in order to encourage the demand for domestic services and proximity services, to create jobs in this sector, and to enable some high-skilled workers (especially women) to (re-)enter the labour market.
<http://www.eurofound.europa.eu/areas/labourmarket/tackling/cases/be004.htm>

Some parts of the labour market have thriving innovation systems. Executive search agencies operate to match highly paid jobs with candidates, individuals pay to invest in their own skills, and employers are willing to pay to invest in senior staff (even though it is the individuals themselves who may benefit most from such investment).

But at the low-end of the labour market, the incentives for innovation are weak. Employers are less willing, or able, to invest in matching services that connect individuals with jobs and in skills development as staff are seen as more easily replaceable. Individuals lack the resources to invest in training themselves even though they are the ones who will reap the main benefit from employability gains. This means that intermediaries (whether they

be traditional employment agencies or welfare-to-work providers) have little financial incentive to innovate.

Government becomes the primary purchaser of such services in an attempt to make the low end of the labour market work better. This brings with it challenges. Government innovation is often plagued with ‘initiativitis’: big-bang projects rolled out universally with inadequate testing.²³⁷ At the same time, the desire to ensure value for money for the tax payer from private sector providers through tight specifications and competitive contracting discourages experimentation and differentiation.²³⁸ Innovations do exist (see box for examples) but they are rare.

In principle, any innovations that can improve the working of the labour market — whether by increasing the quality of supply, or systems of job matching and search, should reduce unemployment and raise growth. The work of Diamond, Mortensen and Pissarides²³⁹ for example shows that interventions that affect the job search process can help or hinder what economists call the ‘natural’ rate of unemployment in a steady state. Their work also highlights potential opportunities to affect the observed asymmetry of the labour market response to the business cycle (sharp in recession, but more muted in recovery).

Whilst labour market programmes such as the Work Programme have used innovative ways of commissioning and contracting, the aims of these programmes, and the content of delivery, are similar to what has been seen in the past. No evidence has yet been published on the extent to which innovation is taking place within the Work Programme.

They also miss out on some of the promising fields of innovation — for example new platforms for job matching are likely to work best if they don’t distinguish users by their welfare status; ways of reshaping schooling to make teenagers job ready (like Studio Schools that go well beyond small slices of work experience to give pupils paid work); and ways of reshaping the very nature of jobs. Some fascinating innovation is underway which aims to speed up the circulation of resources within local economies — using complementary currencies, localised credit creation, or measures to unlock capital assets. Next year, for example, the city of Nantes in France launches a parallel currency for businesses. Hyperlocal media may play a role here, making it easier for people to find and buy reliable services from local providers.

In all of these cases there will be valid objections from vested interests and traditional economists — who often claim that labour markets are already close to optimal. The only way to find out if innovations work is to test them in real world environments. The potential social gains if they work are likely to greatly exceed the costs of experiment.

There is some cause for optimism. The Department for Work and Pensions has launched an Innovation Fund of up to £30 million over three years to support social investment projects. The challenge will be to make sure this is effective in encouraging new approaches.

PROPOSALS

Develop the **DWP’s Innovation Fund** into a more systematic innovation programme for generating, developing, testing and scaling ideas.

Experiment with IT platforms to make it easier for the smallest businesses to employ workers, looking in particular for ways to make these interact better with HMRC systems.

Trial **new payment models** that allow those who invest in the costs of getting people into jobs to recoup their investment. Hypothecating local taxes using a City Deal model is one option.

New labour models

Encourage two to three places to act as laboratories for new types of labour market, testing out a range of new models: from creating or supporting new markets (such as using complementary currencies or online platforms to boost demand in areas of high unemployment), supporting self-employment and using intermediaries to improve the efficiency of job-matching.

Apprenticeships

Shifting the norms and driving a step-change in Apprenticeship models (such as requiring every £1 million of public spending to support at least one apprenticeship).

Enhance evidence

Create an independent evidence centre for the labour market, charged with orchestrating knowledge about emerging approaches worldwide; evidence about what works; and ensuring this is provided in forms that are useable by practitioners and meet their needs.

ENCOURAGING A CULTURE OF INNOVATION

As well as money and systems, innovation depends on people. The ability to innovate isn't innate (although almost everyone has some capacity to be creative). Instead it's more likely to grow when it's encouraged and financed; when it's backed by practical skills, the deep craft of making ideas real; and when there's the right mix of competition and cooperation in organisations, fields and places to push people on. As a rule, well educated, entrepreneurial people living in cosmopolitan environments are more likely to succeed in innovation, though there are plenty of exceptions. Cultures conducive — or hostile — to innovation can appear deep-rooted and hard to change. But there are many examples of countries that have transformed their environment for innovation within the space of a generation. Here we focus on two areas of policy that can strongly enhance the UK's innovation culture: education and our interactions with the wider world, in particular through immigration and foreign relations.

11. Remaking education for a digital age

Education is the biggest investment we make in our economic future. Quality education helps young people develop the skills that enable them to fully participate in society and drive economic growth. It is no coincidence that the countries that top international tables of educational performance, such as Singapore and Finland, are also hotbeds of innovation.

The UK has long been admired for the quality of parts of its schooling and university sector. But it has also suffered from very uneven performance. New developments in education, particularly the explosion of digital technologies open up important opportunities that should be part of any serious strategy for innovation.

The first is the potential for harnessing new, smarter, nearly ubiquitous technologies — from e-mail to digital games to adaptive technologies — to improve the effectiveness of education, and the potential competitiveness of the UK's education industry. After many false starts, a much clearer picture is now emerging about how the full potential of digital technologies can be realised.

The second is the chance to give every young person experiences of making digital products rather than only using them. Projects like Mozilla's Thimble and Apps for Good show what can be accomplished — and should be much more widespread. This is important not only for nurturing the UK's future programmers and games-makers. It's also an important way of giving young people a sense of the fun and fulfilment of being an innovator.

Nesta's 'Next Gen' report set out an ambitious agenda for transforming computing in schools, which government has broadly accepted. The challenge now is to drive its implementation.

Background

Economic growth depends on skills.²⁴⁰ Contributing to productivity, cognitive skills affect our ability to create and adopt new concepts, products and innovations. Non-cognitive skills like creativity, diligence, and teamwork, matter too. As the economy becomes increasingly knowledge-based, we require a broader and deeper range of skills and knowledge to actively participate within it. A majority of UK employers expect an increase in the number of high skilled, leadership and management jobs alongside a decrease in the number of low-skills jobs.²⁴¹ As Andreas Schleicher of the OECD argues: *“routine cognitive skills, the skills that are easiest to teach and easiest to test, are also the skills that are easiest to digitize, automate or outsource.”*²⁴²

Worryingly, we are now seeing increasing skills gaps alongside heightened unemployment — an indication that the workforce is not equipped for the current and future labour market. Already many employers are experiencing difficulty recruiting, in particular those within traditionally technological and STEM sectors — manufacturing, pharmaceuticals, and the digital creative industries.²⁴³

Meanwhile, the UK’s education system is, in a global context, not bad, but not among the best.^{244, 245} Improvement has been steady, but slow. The last decade saw major investment in the education system and some improvements that helped increase the UK’s productivity²⁴⁶ including academy schools, programmes like Teach First and more children staying in school longer, but nothing near transformational change. The current school reforms will, it is hoped, lead to even more improvement.

The bigger challenge of improving the UK’s skills across the board is clearly a vital part of any long-term economic strategy, and of our ability to innovate. Here we focus on just one part of this story: the role of digital technologies and digital fluency as both a goal for education, and as a means.

Harnessing digital technology to reinvent learning

UK governments and schools in the past have spent heavily on technologies which were then left in cupboards or, if they were used, didn’t live up to expectations. Too often these technologies were used simply to digitise existing analogue tools and practices — creating e-books to replace paperbacks and electronic whiteboards to replace blackboards — rather than exploring radically different models. If we have learnt one thing from three decades of the computerisation of the economy, from supermarkets to space flight, it’s that technology can make a huge difference — but only when it’s used to reshape everyday practice.

Fortunately, this is beginning to happen. As Michael Fullan puts it, technology and pedagogy come together to *“take the lid off learning.”*²⁴⁷ A large number of technology products are now available at relatively low cost and with growing evidence about effectiveness. Examples range from apps that make physics easier to grasp by focusing on the flights of an albatross (Aero!);²⁴⁸ to numerous on-line courses from the likes of the Khan Academy, Udacity, and MITx. Many are free and have the potential to achieve significant impact when combined with teachers who can intelligently shape on and off-line learning activities, providing feedback, setting goals, and bringing all these resources together into a consistent whole.

These examples point to radically different ways of organising learning, with teachers playing as much of a role as coaches as transmitters of knowledge. More learning may be done at

home — with school time used to deepen learning, or focus on non-cognitive skills. And more learning can involve structured collaboration and team work, rather than being wholly individualised.

The evidence on what works is still uneven. But one of the other advantages that digital technologies bring is much more data and much more scope to analyse which elements and combinations have the most impact.

To make the most of the new opportunities, many barriers will need to be overcome. Everyday challenges surrounding the school environment and resources — such as child safety, access to devices, firewalls, and so forth — must be resolved. Teachers need more help in getting the most out of technology.²⁴⁹



IMAGE COURTESY OF CDI EUROPE

The Mapp your Way team celebrate with Stephen Bates (BlackBerry)

As in other fields, we need more systematic innovation to find out what really works. New York City, home to 1,700 schools, offers one example of using technology to spread the reach of the best teachers and to personalise learning.²⁵⁰ Both Thailand and Turkey are planning on giving every student a one-on-one device: the point is not the devices but the access that it opens up to the wealth of free education resources out there.²⁵¹ British Columbia, Canada, has ambitions to personalise curricula and pedagogy, and to introduce greater flexibility in where and when learning takes place.²⁵²

Not all of these experiments will work. But we need to be fast to learn both from their successes and failures, and through our own experiments. There will be a pay-off not only for the UK's children but also for the economy.

With one of the largest education sectors (including exports) among all developed economies — and almost certain to grow as a share of GDP — there is an immense economic incentive for British practitioners and providers to innovate.

Digital making

Looking back, the UK's industrial strength was built on the skills of many thousands of makers, who combined an intellectual fascination with the key technologies of their time with the practical skills needed to put them into effect. Societies and clubs brought together thousands of engineers and inventors to share their ideas and to drive each other forward. The digital economy is in some ways radically different from an economy based on ships and steel. But in one way it's very similar — our ability to innovate and prosper will rest on us having a broad base of skills in making as well as using; of being producers as well as consumers. With the advent of massive economic and technological transformations like the Internet of Things, big data, and personal manufacturing, we should take note of past eras of innovation and reconsider our roles as makers in the digital age.

For young people to become makers and masters of the digital world, they need to be engaged in their own learning and able to see its application in their future lives, work and society. Making tangible products is a fantastic way to achieve this, yet a long-standing complaint about the UK's school systems has been that many classrooms still present knowledge in a way that is divorced from its real world application.²⁵³ This is despite calls from industry for a different approach — for example, when Nesta worked with the UK's video games and visual effects industries on the 'Next Gen' report, to identify the skills they needed to succeed in the future, a lack of practical learning within ICT at school was one of their biggest complaints.²⁵⁴ Similar challenges can be found in almost any subject.

We don't have to look far to see examples that point to a better approach. Programmes like Young Rewired State bring together young coders over a weekend to code and learn, under the tag line 'Coding a Better Country'. In the Apps for Good programme students work to create Apps that address real world problems using design thinking: one group of students have created a Stop and Search app, available for download that *"allows young people to rate their experience of being stopped and search(ed) by the police."*²⁵⁵ In this year's Apps for Good programme, Nesta sponsored the 'learning' category where young people designed apps to make their learning more engaging and deeper. There are many other examples: Coder Dojo, Code Club, Ladies who Code, and Dare to Be Digital.

These programmes succeed in blending coding and the making of digital things with equally valuable experiences of creativity, problem solving, collaboration, and experimentation. It is precisely these types of activity that make real the desire to get more entrepreneurship, innovative behaviour even, into

schools and wherever else young people are learning. Other programmes show how technology itself can be used to deliver great digital making learning opportunities: for example, working with the Mozilla Foundation, Nesta has supported the development of a product called Thimble²⁵⁶ which allows students to learn HTML/CSS code by doing — students alter the code to effect immediate changes in web content. And young people and schools want these opportunities — Apps for Good has spread to over 40 schools across the UK within two years²⁵⁷ while MIT's collaborative coding platform, Scratch, has over 1 million registered users worldwide and 2.7 million projects uploaded.²⁵⁸ With the right support, and more widespread distribution, these programmes could create a new generation of digital makers.

Nesta has in 'Next Gen' argued that such programmes need to be supported by deep changes in the school curriculum which promote the teaching of computer science.²⁵⁹ This should include providing incentives to schools to teach it by including rigorous GCSE qualifications in computer science in the English Baccalaureate. A campaign, Next Gen Skills, led by UK Interactive Entertainment (UKIE) has been set up to take forward this agenda.



IMAGE COURTESY OF PAUL CLARKE

Taking part in the Mozilla Learning Jam

While we need to encourage and make young people aware of what's out there, supporters of digital making also need to bring their opportunities to where young people are. Successful initiatives like the BBC Computer Literacy Project have taught us that, *"delivering change means addressing the home not just schools."*²⁶⁰ Breaking down false distinctions of where education is and isn't supposed to happen, digital making can occur in school and at home, but also within youth organisations and centres as well as in museums, the shopping centre, sports centres and just about anywhere else. Initiatives like the Hive Network in New York and Chicago are creating communities of civic and cultural institutions to "transform the learning landscape" by opening spaces and opportunities for learning across their respective cities.²⁶¹

As young people pursue learning through digital making, they will partake in experiences and develop skills that fall outside of formal accreditation schemes. If increasing skills is important to economic growth (and it is), then we need to get past narrow conceptions of credentialing and begin to think about how skills and learning in informal, practical and non-traditional contexts can also be assessed and recognised.

Some employers now offer challenges and exercises to job applicants as a means of demonstrating their knowledge and experience. Websites like interviewstreet.com are accelerating this approach in the computer programming sector.²⁶² More broadly, organisations have also taken inspiration from the Scouts movement and begun to create digital badges to capture and demonstrate skills developed informally. In the UK, RadioWaves and DigitalME are currently piloting digital badges that recognise skills gains by young reporters, ranging from technical skills like interviewing to transferrable skills such as collaboration and mentoring.

These new models for qualifying and assessing skills are significant: they open opportunities to anyone with the interest and determination to learn new and interesting skills, and demonstrate their achievements to academic institutions and employers alike. They reshape our conception of where learning takes place — an important consideration as what and how we learn also transform.

PROPOSALS

Educating a generation of digital makers

We live in a digital world, but are not equipping our young people for it. The UK needs more opportunities, resources, tools, and services that enable digital making. Organisations like Apps for Good, Young Rewired State, the Raspberry Pi Foundation, and many others are already passionately working to engage as many young people as possible in digital making activities. All these initiatives deserve greater support and prominence. Likewise, the recent disapplication of ICT in favour of computer science has opened the door for a new range of opportunities to learn about and through digital technology in school.

What is needed is a national campaign, backed by leading businesses, organisations and public institutions, to bring this message to schools, to homes and into everyday life. There is a powerful example we can take inspiration from: the BBC's Computer Literacy Project. In the early 1980s, this project combined the mass media of the day (TV) with school resources and hands-on work with businesses (including Acorn, the start-up

that designed the BBC Micro, and later gave rise to ARM Holdings, now the UK's biggest technology company). Many of the pieces are already here — indeed, more organisations are promoting coding and making to young people than ever before, with many having received support and encouragement from businesses and the Government. All that remains is to make a coordinated push to bring the imperative of digital making into the mainstream.

Along with partners, Nesta is taking the steps to initiate this process; but it is not something that can be done without the support of others. Stakeholders in digital making — including organisations, education providers, cultural and public institutions, and industry representatives — need to come together as a consortium and use their collective strength to raise the profile, and support the creation and scaling of, opportunities for digital making across the UK.

Improve the supply and demand for technology-led products that support learning

Insufficient investment is being devoted to the development of break-through ideas, leading to an overabundance of products failing to exploit the necessary combination of pedagogy plus technology that we have been arguing for. With insufficient collaboration between practitioners, academia, technologists, and creative talent, we are failing to make best use of the talents and skills that the UK possesses. This is bad for students and for the future health of the UK's education export market.

We need to do better by being more rigorous, more open, and by investing more in our capacity to innovate in education. To meet these challenges we recommend two approaches: much like the NHS commissioning process, education systems across the UK should test and develop a platform where persistent learning challenges are posted to an open group of suppliers who are incentivised to respond. Those with promise should be rigorously evaluated to produce a 'Which?' style report that schools can use.

Equally, a set of incentives, such as challenge prizes, should be developed to spur innovation in areas that can deliver high-returns for learning (see section 6: Incentives for Innovators). For example, the similarities between great learning and the best computer games are well known, yet little has been done to incentivise the UK's games industry to collaborate with educationalists to produce games that deliver learning gains and are fun. For a glimpse of the possibilities of games to tackle big and important topics, we can look at Play the End, a game for teenagers which asks questions like 'can we understand what death is actually like?' It has had over 10,000 Facebook 'likes,' with players answering over one million questions.

Develop tools to recognise and assess informal learning and skills development

With the advent of resources and communities such as FabLabs, Codecademy and Udacity, it has never been easier to connect, learn, and develop skills outside of the classroom. But how can learners demonstrate their skills and gain recognition for their achievements? We need to rethink how we recognise and distinguish learning that takes place outside of formal institutions.

Already, some employers assess applicants' skills through online challenges and tasks. Likewise, organisations in the UK and abroad are now building digital badges that recognise skills gained through informal activities. Still in their infancy, digital badges need to be developed, tested and integrated within education and work channels. However, if successful, their impact could be massive.

Like the open courseware movement, new methods for qualifying informal skills could radically democratise access to educational and professional opportunities for learners. Employers would also benefit by broadening the pool of talented and experienced applicants. For this to be successful, educational and professional institutions will need to be onside and willing to open up the right to accredit and badge skills. In the US, NASA is currently developing a series of badges for STEM and robotics which will be used to assist in selecting interns.²⁶³ Our educational institutions and employers need to take note of these burgeoning strategies and follow suit by creating, supporting or endorsing quality badges and frameworks for their use.

12. Breaking down barriers — to entrepreneurship and to the wider world

Innovation depends on entrepreneurial spirit. It requires risk-takers who are willing to take a new perspective on a problem, challenge the status quo, and build new ventures. That kind of entrepreneurship thrives best in an open society: one that is open to new ideas, new people and new market entrants.

The UK makes much of its openness. But recent policies to limit migration send a very different signal, as moves to push out foreign students at the earliest opportunity. Moreover we don't do enough to attract in resources from those parts of the world that are rich in capital, or to ease the way for inward investors. As countries like China, India and Brazil become innovation hot-spots, we stand to gain from building connections with them, just as the UK's scientists and businesses already benefit from taking part in global networks.

And there is more that can be done to give entrepreneurs a fair crack at success. Some of the barriers to entrepreneurship are deep-rooted and slow to change. Movements like Start Up Britain are gradually breaking them down, and deserve our vocal support. Other barriers fall within the remit of public policy. In particular, our regulatory regimes and competition rules often deter new entrants, making sectors like banking more concentrated than they need to be.

Background

Innovation, entrepreneurship and openness are intimately linked. Entrepreneurs and the new businesses they found are disproportionately likely to come up with radical innovations that disrupt markets.²⁶⁴ Innovators are more likely to be open to new experiences and influences than the average citizen.²⁶⁵ And open, tolerant societies put fewer barriers in the way of entrepreneurs, new ideas and new market entrants.²⁶⁶ This triad of innovation, entrepreneurship and openness has led to remarkable prosperity.²⁶⁷

A look at the world's most innovative economies provides good evidence for this link. They are generally open to external influences. Melting pots like Silicon Valley or Israel are home to people from a range of nationalities, many of whom are highly skilled and highly entrepreneurial. Even more homogeneous innovative nations, such as Korea or Finland, are extremely open to outside influences and have built their success on trade and being at the international cutting edge.

Innovative countries also tend to be entrepreneurial. The reputation of Silicon Valley and Israel as cradles of tech start-ups is well known. Scandinavia's innovative economies make it easy for entrepreneurs to start new businesses, while researchers have noted the importance of entrepreneurs in the meteoric economic growth of Asian economies like Korea.²⁶⁸

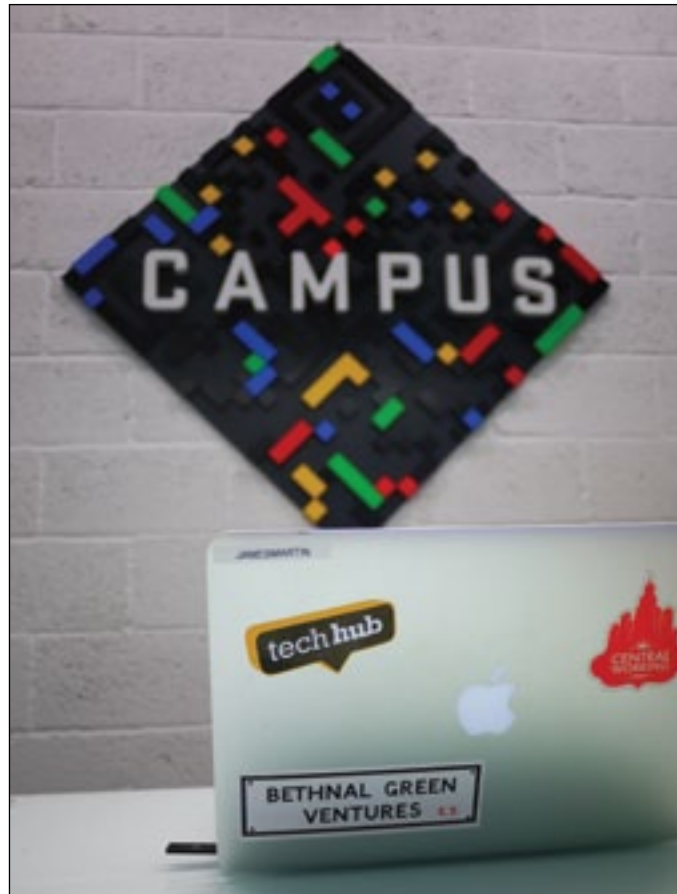
UK policy certainly recognises the importance of both openness and entrepreneurship to innovation. Entrepreneurs have their own adviser in Number 10, the vocal support of politicians, and a range of tax breaks and loans. International openness also benefits from government policy. Within the EU (at which level most trade agreements are negotiated),

the UK is a strong voice for openness in the form of free trade. The UK is the world's largest exporter of services, and plays host to many export-oriented manufacturing businesses too. When it comes to openness to ideas, the Department for Business, Innovation and Skills and the Research Councils have begun to reach out to researchers in BRICs countries, and have built several promising research partnerships. When it comes to immigration, there have been well intentioned efforts to mitigate the effect of the Government's net migration target through easing the process for intercompany transfers and creating the Entrepreneur's Visa scheme.

However, there are countervailing forces.

Just when we need the ideas and talents of the world's brightest innovators, we are turning our back on them. We send talented new graduates and postgraduates with valuable skills in science, engineering, design, and more back to their countries of origin in the name of an arbitrary quota, starving our businesses of some of the world's best talent. Although we fill our universities with foreign students and gladly accept their tuition fees, we too often see them as transients and cash-cows. This reduces the quality of the education they receive here and undermines their long-term relationship with the UK. The exemptions agreed so far from the immigration cap look more focused on the interests of big corporates (e.g. the rules on intercompany transfers) and big money (the exemptions for large investors) than on giving the UK the world's most innovative workforce.

Research supports the idea that immigration can spur innovation. Studies show that a one percentage point rise in the number of immigrant graduates in the population raises the number of patents in the wider population by 15 per cent;²⁶⁹ that the arrival of star scientists encourages innovation in countries that receive



IMAGES COURTESY OF PAUL MILLER

Google Campus co-working space in Tech City, East London

them; and that the arrival of foreign graduates boosts innovation²⁷⁰ in receiving countries and regions. A quarter of the engineering and technology companies started in the US from 1995 to 2005 had at least one founder who was foreign-born; in Silicon Valley, this figure rose to 52 per cent.²⁷¹

The UK's borders are not the only barrier to entrepreneurship. Entering new markets in the UK can be hard too. Some industries, most notably banking, look remarkably concentrated.²⁷² The UK's competition policy has made considerable progress to increasing competition in some sectors in the last decade,²⁷³ but there is more that can be done. In the financial services sector, for example, new businesses find the process of getting regulatory approval can be so time consuming that it makes developing new businesses extremely difficult.²⁷⁴ In other sectors, changes to the rules may entrench incumbents²⁷⁵ — proposals to end net neutrality could have this effect for many online content providers, by raising the cost of delivering bandwidth-intensive services.²⁷⁶

PROPOSALS

Greater openness to talent

We recommend removing the immigration quota for highly skilled workers, whether they be young people who have recently received degrees in in-demand subjects at UK universities, or experienced workers with track records in important industries. One way of doing this without allowing unrestricted immigration — which would likely prove politically unpalatable — is to emulate the quota systems put in place in Canada and Australia. But however it is implemented, there should be a presumption that talented graduates from outside the EU who study in the UK should be seen as a desirable asset, and that we should want them to stay, not force them out, and that employees of fast-growing companies backed by reputable VCs or angel investors should be welcomed.

Welcoming the world's best

Indeed, our policies should go further than this. Highly skilled foreign workers are not just potential employees and entrepreneurs. They also offer a link to their home countries. To make the most of this, we should actively seek to create opportunities for the most talented foreign students while they are in the UK, to maximise the quality of their experience and the ties of obligation between our country and theirs.

A great example of what can be done is Made In China, a networking club that allows the best Chinese students in the UK to meet leading UK creative businesses and start-ups, providing training on doing business in Britain and internships with leading businesses. These kinds of initiatives should be encouraged and promoted both by leading universities and businesses. To take this idea further, we recommend experimenting with a fund to provide start-up loans for the most talented overseas students who start businesses in the UK. Arguably this would represent a far more effective and cheaper way to establish strong links with the most innovative aspects of BRICs countries than expensive government-funded research partnerships.

Helping entrepreneurs thrive

At the same time, we should seek to encourage entrepreneurs. The government is right to throw its support behind existing programmes that give entrepreneurs practical help, such as London's Google Campus, the European accelerator Seedcamp or the Welsh incubator Alacrity, and to projects that promote entrepreneurship, such as Start Up Britain. We would

like to see such programmes go much further, and focus on growing businesses as well as starting them. Perhaps it is time for 'Scale Up Britain'.

Breaking down barriers to entrepreneurship

Regulation also has an important role to play. All regulation, whether in the financial services sector, the utilities sector or beyond, should include the principle of encouraging new entrants into markets. In some cases, this will involve ensuring that the regulatory process for approving new innovations is as swift as it can reasonably be; in others, such as the example of net neutrality, it will involve making sure that changes to regulations do not end up favouring incumbents over new competitors. But the core principle should be fixed: regulation should not unwittingly suppress entrepreneurship.

CONCLUSION

This section has provided a range of policy recommendations in 12 areas, from finance to education and from the technicalities of innovation measurement to the culture surrounding innovation. Some proposals can be acted on swiftly, such as earmarking the proceeds of the 4G auction for innovation or involving designers and accelerators in the set-up of Catapult centres; some will take years to implement fully, such as the recommendations for increasing the sources of patient capital in the UK. But taken together, they offer a way to make the UK a better place for businesses and citizens to invest in innovation, which will help us on the road to sustainable economic growth.

Nesta and partner organisations will be following up Plan I with more detailed proposals, as well as our own actions as an investor, as a funder of programmes in fields such as digital education, and through initiatives such as the Centre for Challenge Prizes. A manifesto for the Creative Economy focusing on the creative industries will be published early in 2013. We welcome comments, ideas and improvements on both the diagnosis and the prescription of Plan I. The best innovations evolve and adapt. The same is true of the best innovation policies and we present this as a work in progress.

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