Go for Growth

A response to the Green Paper on industrial strategy prepared by Phil Mullan, James Woudhuysen, Andy Shaw and Rob Lyons on behalf of the Institute of Ideas Economy Forum

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IOI ECONOMY FORUM

Executive summary

We welcome the Green Paper as an opportunity for fresh ideas on the issues of productivity and economic growth. There has been a lack of serious thinking and effective action about these issues for many years. As a result, the UK economy has consistently lagged behind even the relatively weak rates of investment and productivity growth in other advanced economies.

While action on the various problems with the UK economy is long overdue, our departure from the European Union offers a chance for thorough reflection upon this state of affairs. We argue that many elements of current policy need to be changed. Some of these changes will be controversial in the short term and will require considerable resolution on the part of Government to follow them through. We believe, however, that we are long past the time when the UK can afford to muddle through. Our proposals would provide the basis, not merely for riding out any economic problems resulting from Brexit, but also of a new surge in wealth creation in the UK.

The papers that follow look specifically at three areas of the consultation:

1. 'Extending our strengths', 'Closing the gap' and the 'ten pillars' for raising productivity

While 'catching up' may be an appropriate outlook for a developing economy, it is not suitable for an economy like the UK that is already advanced. Our strategy must be to facilitate the transformation to a stronger future, not reinforce the present state of affairs. In that case, we must identify the barriers to raising productivity and the creation of new firms and industries.

First, we must get serious about publicly funded research and development (R&D). At present, publicly funded R&D spending equates to about 0.5 per cent of GDP; public and private sector spending together equates to 1.7 per cent of GDP. This is far less than both EU targets and many of our major competitors. We propose that publicly funded R&D spending should rise to two per cent of GDP as soon as possible – enabling the kind of 'blue skies' and basic research that is the bedrock of future products and services.

Second, we need to revive a powerful motor for economic transformation: creative destruction. At present, a relatively small number of companies provide all of the UK's productivity growth. Far too many firms are 'zombies': kept on life support thanks to easy credit and supportive regulation. Sustaining these firms is a barrier to new investment and innovation among more dynamic firms. Japan's 'lost decades' are testament to the dangers of weakening business 'churn', even where R&D levels are healthy.

We agree with the Green Paper that 'modern British industrial strategy must make this country a fertile ground for new businesses and new industries which will challenge and, in some cases, displace the companies and industries of today'. This can be achieved, for

example, through changing insolvency rules and ending the policy of ultra-low interest rates. Bank of England independence should end so that interest rate policies can be guided by Government policy. A broad review of regulations should be undertaken with a view to kick-starting the process of creative destruction and ending the mollycoddling of incumbent but under-performing firms.

This renewed dynamic of creative destruction will be painful, however. It must be allied to support for employees so that they take up jobs in new firms and sectors as they emerge. In the long run, this support will pay for itself as workers find more appropriate outlets for their abilities and economic growth takes off.

2. Priority areas for science, research and investment

The case for industrial strategy in the broadest sense has been handicapped by accusations about Government attempts to 'pick winners' in the past. In reality, policy has been more directed at propping up losers than supporting potential winners. The Green Paper is right to emphasise the need for new industries that are sustainable, competitive, generate substantial new wealth and offer plenty of well-paid jobs. The Green Paper is also right to identify on page 15 a number of sectors worthy of special attention around energy, robotics and artificial intelligence, space technology, healthcare, and more, with particular interest in battery technology.

We offer further suggestions for new sectors that could meet the Green Paper's exacting requirements: mass-manufactured housing (with the important proviso of releasing Green Belt land for development); clever pipes, utilising 'internet of things' technology; combining pharmaceuticals, medical devices and digital health; a new infrastructure to take advantage of recycling carbon; and service robots for older people.

More generally, we need a focus on enabling technologies that facilitate the journey from the lab to market, including lab equipment, digital design modeling and 3D printing, allied to 'agile' product development strategies borrowed from software development.

What must be central to Government strategy is demand as well as supply. What new technologies do we know will be needed in the future? This emphasis will avoid the mistakes of the past. But this must also be allied to a major expansion of 'blue sky' research, so that we are open to new, unthought-of opportunities.

3. Cutting energy costs

Productivity increases are driven, in substantial measure, by the clever replacement of human labour by other energy sources. Therefore, increasing the potential supply of energy, while cutting its cost, is a crucial element of creating a dynamic UK economy in the future.

Unfortunately, the drive to decarbonise energy has all too often taken precedence over cutting costs and increasing supply. We therefore argue that it is time to scrap the

framework created by the Climate Change Act, which has increased bills substantially for both domestic and business users. We think an ambitious target should be set: to *halve* the cost of energy. This would be a popular move that also provides a stimulus to innovation.

Energy subsidies should be phased out quickly. Low-carbon technologies will flourish where they meet the wider requirements of society. Extraction of shale gas through so-called 'fracking' techniques, which are safe, economic and do not require subsidy, should receive more enthusiastic backing from central Government. Local authorities should be allowed to keep more of the benefits of shale gas extraction as an incentive. A single-minded drive to create new energy technologies – a 'Manhattan Project' for energy – should be instigated. These new technologies may well be low-carbon, but that should be a happy side effect of innovation, not the primary focus.

About the Institute of Ideas Economy Forum

The Institute of Ideas was founded in 2000 to provide a forum committed to open and robust public debate in which ideas can be interrogated, argued for and fought over. The Institute organises intelligent public debates, on controversial topics, and most importantly challenges contemporary knee-jerk orthodoxies.

The Institute's Economy Forum was started in 2008, meeting regularly to discuss a wide variety of economy-related issues. Recent Forum discussions have, for example, covered behavioural economics, 'gig' working and the sharing economy, the Internet of Things, and recent trends in world trade.

SECTION ONE

Foster new sectors

Phil Mullan

The questions responded to:

1. *Does this document identity the right areas of focus: extending our strengths; closing the gaps; and making the UK one of the most competitive places to start or grow a business?*

2. *Are the ten pillars suggested the right ones to tackle low productivity and unbalanced growth? If not, which areas are missing?*

Introduction: set the conditions for brand-new sectors of production

It is welcome that the Government has launched a consultation around 'Building our Industrial Strategy'. The goal of making such a strategy *effective* depends first on having a meaningful consultation that explores new approaches. Too many times in the past, in this country and in other advanced economies, 'modern' industrial strategies have been launched to little positive effect in the succeeding years. Instead, pre-existing economic trends have mostly continued as before.

This ineffectiveness is usually because governments adopting industrial strategies have at the outset jumped the crucial stage of identifying the fundamental barriers to further economic development. Partly, this is out of a desire to get on and simply do something. Partly, it is because some experts believe that the advanced economies are already at the frontier of most existing technologies. As a result, the focus for industrial policies easily slips into *building on what is already in place*, and maybe rectifying any shortcomings relative to other advanced countries. This is far from enough to reinvigorate today's tired mature economies.

To set the objective of 'catching up' with the best technologies available is a legitimate initial goal for today's less developed countries. But for mature economies, the goal should be: *ensuring the very best are able to keep reinventing themselves, and creating the conditions for the wholly new to develop*. It must be about facilitating transformation to a stronger future, not reinforcing the present.

Unfortunately, this Green Paper risks going down that same path with its emphasis on 'extending our strengths' and 'closing the gaps'. Instead, the government should focus on *bringing about what doesn't yet exist*, not on adjusting and extending what does exist. Any

country's economic prospects five, 10 or 20 years hence depend not on its current capabilities – or lack thereof – but on the assets and strengths which have yet to be realised, possibly even to be imagined.

Recall the approach of Adam Smith and other Enlightenment authors at the end of the eighteenth century. They wrote during the early stages of the first industrial revolution; but they could not foresee which technologies and sectors would take off during the early nineteenth century. Smith didn't anticipate the epoch-changing impact of steam engines or railways, for they were still to be invented when he was writing *The Wealth of Nations*.

What Smith and his fellow thinkers did was encourage the state to set the commercial conditions in which innovators could thrive and new sectors expand. Similarly today: to give Britain a prosperous twenty-first century, we must acknowledge that it is sectors and businesses that are currently largely unknown and possibly even unimagined that will really drive productivity and employment growth.

Old sectors vs new ones

It is reasonable to identify certain existing sectors that have more potential to develop and expand. The Green Paper, for instance, mentions automobiles and ultra-low emission vehicles, artificial intelligence and satellite technology, aerospace, life sciences, industrial digitalisation and nuclear energy. But it is even more important that an industrial strategy's sector policy doesn't limit horizons to what can already be identified. Britain's future economy will not ensure prosperity for everyone if it remains limited to the economic sectors of today.

A word about sectors

This response does not take the 'industrial' in 'industrial strategy' too literally. For economic transformation, we are talking about sectors of production which include manufacturing, process industries and extractive industries, but which also stretch from agriculture, through construction, to services.

An effective industrial strategy therefore needs to guard against a mentality that targets initiatives on existing sectors, at the expense of setting the conditions for brand new, still-to-be-born ones.

The good news is that setting the conditions for new sectors of production has nothing to do with 'picking winners', or even picking the 'next' winners – approaches about which the Green Paper is rightly sceptical. Rather, setting the conditions for a real economic renaissance demands that policymakers assess, in depth, why new sectors of production and the new, high-value jobs that go with them have for years largely eluded us. **Identifying and removing the barriers to new industry formation is the best thing governments can do to realise the benefits of industrial strategy.**

Hence this consultation response is framed as an answer to Questions 1 and 2. This submission believes the Green Paper does not identity the most important areas of focus (Question 1) and suggests other, better areas in which Britain could successfully tackle low productivity (Question 2).

Get serious about public spending on R&D

For the Green Paper, the goal is policies that 'help to deliver a stronger economy'. The Secretary of State for Business, Energy and Industrial Strategy, Greg Clark, spelt this out further in his foreword. The aim is 'to improve living standards and economic growth by increasing productivity and driving growth across the whole country'. The importance of productivity for living standards is properly acknowledged, as is the weak performance of productivity growth over recent years. This emphasis on acting to revive economic growth, and especially the growth in *productivity*, is entirely justified.

In her opening remarks for the Green Paper, the Prime Minister also explicitly recognises low productivity as the British economy's 'underlying weakness'. She continues with the clear and unambiguous point that if we want to increase our overall prosperity 'we have to raise our productivity'. However, the themes taken up in the Green Paper fail to grapple sufficiently with this core problem. That is why the Green paper also falls short in proposing the bold steps necessary to reinvigorate its growth.

The Green Paper's 10 pillars of industrial strategy do include important proposals that could, in suitable circumstances, make a genuine difference to productivity, even if they often don't go far enough. For instance, the Green Paper is right to indicate, with Pillar One, that inadequate research and development (R&D) limits the possibility of making the discoveries, inventions and the follow-on innovations necessary for productivity growth over the longer term.

In the UK, both business and public spending on R&D fall far below what is needed. Each has been on a declining trend since the 1980s: for the year 2014, the OECD puts UK business enterprise expenditure on R&D as equivalent to 1.1 per cent of GDP, while government-financed R&D is 0.5 per cent.[1] For the year 2015, the OECD puts Britain's overall R&D at 1.7 per cent of GDP. This level of commitment represents little more than *half* the EU's target of three per cent of GDP by 2020. Compared with R&D commitments in 2015, it is behind China (2.1 per cent of GDP), well behind the US (2.8), and not even in the same race as Japan (3.5) or Korea (4.2). [2]

Our response to the Green Paper favours an increase in public spending on R&D to *two per cent of GDP*, well over three times the level supported by current plans. Of course, such an increase in government-backed R&D will not guarantee, as an outcome, three times the level of commercial British innovation. But continuing with the current, thoroughly anaemic levels of public R&D will, and in a quite irresponsible way, *guarantee* relatively low levels of innovation.

The public spending increases already announced by this government for the years until 2020 fall far short of what is needed. These will raise public spending on R&D by 0.1 per cent of GDP. Much more government fidelity to R&D spending needs to be sustained over the next decade. That would help reverse the effects of years of declining spend by successive British governments – and, it should be added, by most British businesses.

Bring back creative destruction

Pillar Four highlights another crucial area for necessary change: the productivity benefits from higher rates of capital investment. But the existing pillars don't get to grips with *why* capital investment has been so lacking. Given the relatively low cost and easy availability of business credit, both before and since the financial crisis, the focus in the Green Paper on easing access to funding is misplaced. In some circumstances, it is even counter-productive. The deeper reasons for the shortage of investment that has been such a drag on productivity growth are hardly explored.

The Green Paper does suggest some useful investment measures, not least when it wants more seed and early-stage venture capital funding to help genuine startups – those employing people – to experiment, innovate and grow. Most startups will not succeed, but without more of these risk-taking efforts productivity growth will be handicapped. However, until the structural constraints on business dynamism are dealt with, even these pro-entrepreneurial proposals will be much less effective than they could be. State-backed venture capital funding could simply go to the safest, established startups, leaving younger, riskier firms starved of cash. That would stifle innovation, not foster it.

This point illustrates the most important shortcoming in the Green Paper. Many of its proposals risk *perpetuating the productivity problem by supporting existing businesses, rather than by starting a durable, full-on revival of economic dynamism*. These two are very different approaches. Acting to soften the impact of failures among individual businesses, helping these businesses survive – that is not the same as acting to reverse economic failure, or, where there is failure, intervening to drive forward development. In fact, *reinvigorating an economy means more change, not more stability*. The 'exit' of many existing businesses is a *necessary* feature of the advance of a market economy. This has been the historical experience since the first industrial revolution.

Britain's economy, like several other mature industrial economies, needs to resuscitate *the process of creative destruction* – the way in which older, less productive firms close down and are replaced by newer, more productive ones. This long-established feature of capitalism has been much less in evidence since the 1980s. Reviving creative destruction will usher in a different culture and business climate from that of the past quarter-century, so that new, high-productivity businesses can set up or expand more easily to take the place of existing lower productivity ones.

Such a return to higher levels of business dynamism will need to go hand in hand with comprehensive measures to assist people during the transition between jobs. These *transitional measures* are necessary because displaced workers and their families deserve generous public financial assistance as they transfer to good new jobs. After all, these new jobs are unlikely to emerge immediately or in the most convenient locations. The assistance given should include real help to find new jobs and, if required, to move house to be near them, and publicly-funded training in association with the training provided by the new employers. The costs of this aspect of change can be recouped from the stronger economic growth that ensues from economic restructuring.

Although the Green Paper did not discuss creative destruction explicitly, it was notable that Greg Clark did appear to embrace it. In his foreword, he stated that a 'modern British industrial strategy must make this country a fertile ground for new businesses and new industries which will challenge and, in some cases, displace the companies and industries of today'. Unfortunately, the Green Paper does not pursue this point much. This is a serious omission that undermines achieving the stated objective of a more productive economy. It needs to be rectified.

Not enough diffusion of innovations…

To fix Britain's dismal productivity demands that we understand its roots. In fact, until this understanding is achieved, spending more on industrial strategy risks making a bad situation worse. Why? Because *many public policies have acted to preserve the status quo, to save the existing economy*. That has had the perverse if unintended effect of perpetuating low productivity.

The big question is what is holding back the advance of productivity. The answer, in both private and public sectors, is not enough investment in advanced, innovating technologies. The Green Paper recognises this is a long-running problem. The UK has ranked in the lowest 25 per cent of all developed countries for fixed capital investment in 48 out of the last 55 years, and in the lowest 10 per cent for 16 of the last 21 years (p 63). Unfortunately, recognition of this poor record is not matched by analysis of why investment has been inadequate.

In practice, economy-wide productivity growth is the result of interacting factors, all of which centre primarily on business investment:

- First, *innovation* to develop and deploy new process and product technologies by the leading or 'frontier' companies, whether large or small;
- Second, the spread, or *diffusion*, of these new technologies across the rest of the economy; and
- Third, *business churn*, or the turnover of Britain's stock of businesses, as less productive firms downsize or close, while more productive firms – existing and startups – expand.

Out of this triad of productivity mechanisms, the economic problem lies much more in the second and third areas than in the first. Without them, the spread of innovations across whole economies and the establishment of new sectors of economic activity are both constrained. This is the main reason aggregate productivity growth has slowed.

These two areas are where an industrial strategy for today needs to start and give much of its initial focus. Despite Britain's weakness in private and public R&D, it still possesses plenty of frontier firms that are innovating, even if not as widely or rapidly as in earlier stages of economic development. Many of these frontier firms are likely to continue to do so with or without a new industrial strategy. But in Britain, as in other advanced economies, the other two connected processes of diffusion and business churn have been malfunctioning.

Researchers at the Organisation for Economic Co-operation and Development (OECD) have concluded that the main source of the recent productivity slowdown across the advanced economies, not just in Britain, is a breakdown of the diffusion machine. They found little slowing of innovation by the most globally advanced firms, but rather a slowing of the pace at which innovations spread throughout the economy. Indeed, the OECD discovered that while the productivity growth of the globally most productive firms remained fairly robust in the twenty-first century, the gap between those high-productivity firms (the 'frontier' firms) and the rest (the 'laggards') had risen. [3]

Complementary micro-level analysis by OECD researchers using company data across 24 OECD countries, including Britain, confirmed a widening of technological, innovation and productivity divergence between the top five per cent of firms and the other 95 per cent. [4] Using data from 1997 to 2014, this study found a slowdown in the usual productivity convergence expected as weaker firms 'catch up' by deploying the available better technologies. At the same time the growth-enhancing reallocation of resources from weaker to stronger firms has been less in evidence.

This increasing divergence in productivity both reflects and reinforces a slowdown in the technological diffusion process within national economies. Interestingly, new technologies developed at the global frontier are spreading more and more rapidly *across borders* to other countries even though their diffusion to all firms *within* any economy is slower and slower. [5] This indicates that the in-country diffusion slowdown is unlikely to be anything to do with the *type* of technologies being developed, such as being more digitised or information-based. Instead, the transmission problem is located within the respective national economies.

… not enough business churn

Accompanying the second and third processes, the 'between-firm' contribution to productivity – the *displacement of less efficient firms by more efficient ones* – is substantial. For overall levels of national productivity, it can be more important than the 'within-firm'

effect, in which individual firms, sometimes by pioneering innovation, sometimes by taking in innovations diffused to them, simply become more efficient. Healthy business dynamism, in the sense of businesses closing and opening, is necessary to facilitate a continuing shift of resources from low productivity to higher productivity areas. Unless Britain's resources of people and capital can move out of less productive areas to allow more productive ones to establish and expand, then economy-wide aggregate productivity will suffer.

OECD studies of commercial competition show that the between-firm driver of productivity can determine from 45 to 65 per cent of its growth; within-firm effects make up the balance. [6] One study of UK productivity growth found that 79 per cent of growth came from the between-firm effects. [7]

The creative destruction process underpins this between-firm effect, and it has not been working well. Across the British economy, the rate of business liquidation is historically low. Fewer employment-creating businesses are starting up, and too few of these are expanding through capital investment and recruitment as rapidly as they used to.

At the same time, fewer established businesses are investing and expanding. This includes frontier companies, which are somewhat paralysed by operating in a low-growth, sclerotic environment – one that encourages short-termism and aversion to risk.

Weak UK economic dynamism and low business churn can even numb the country's leading firms in innovation, in sectors such as aerospace and pharmaceuticals. So long as little creative destruction prevails outside the confines of a frontier company, Britain's technology giants will feel little compulsion really to strike out on a new path in terms of innovation.

Both the processes of innovation diffusion and business churn must be fixed for sustained productivity growth to be achieved. Leading firms need to do more; at an aggregate level, Britain's business base needs to do better, too. These are not recent problems, and they long precede the 2008 financial crash, so they are most unlikely to heal themselves. Restoring business dynamism must, therefore, remain the watchword of industrial strategy.

Zombie firms and the relevance of Japan's lost decades

The OECD studies cited above highlight that the major problem accounting for the productivity slowdown is not an absolute disappearance of investment and innovation, but the wider economic atrophy that hinders their spread. This has brought about what many now term a 'zombie' economy: too many resources are stuck in low productivity areas and in 'zombie' firms. The latter are businesses that are too weak to invest in transforming their basic operations. That slows down the diffusion of innovations. At the same time, zombie firms have enough income from somewhere to survive. In that way, they hold back the between-firm creative destruction effect.

Zombie firms spread *congestion* across the economy. In turn, that has a dampening effect on the investment plans of startups and existing viable businesses. Aggregate national productivity is held down. First, more low-productivity businesses hang on. Second, fewer higher-productivity businesses set up or expand, because they're constrained by a sclerotic economy. Further OECD analysis of business churn confirms the decline in dynamism as expressed in a lower rate of businesses setting up. [8] Overall, innovation slows and productivity growth suffers.

The Japanese experience during its 'lost decades' since the early 1990s illustrates the contribution from the rise of zombie businesses to falling levels of investment and a weak level of productive transformation. While other specific features of the Japanese economy were also at work, it is striking that investment and employment growth for healthy 'non-zombie' firms in Japan fell as the percentage of zombies in their industrial sector rose. One study showed that zombification depressed Japanese business investment by between four per cent and 36 per cent per year, depending on sector of production. In those sectors with the most zombie firms, job creation was especially weak, while those sectors where zombies became more important had the worst productivity growth. [9]

The distortions that the zombie regime brought to Japan included firms having to depress market prices for their products, firms raising market wages as zombies hung on to workers, despite their declining productivity, and, more generally, congesting the markets where they operated.

Ricardo Caballero, Takeo Hoshi and Anil Kashyap explain how normal competitive outcomes, whereby these Japanese zombie firms would shed workers and lose market share, were thwarted. The resulting artificial oversupply that lowered prices and raised wages reduced the profits and collateral that new and more productive firms could generate, thereby discouraging their entry and making investments.

The congestion caused by the zombies delays more productive projects and the entry of more productive firms.[10] Negative perceptions of the risks of business investment and expansion are exacerbated. The artificial maintenance of oversupply made it more difficult both for the stronger incumbent businesses and for new ones to adopt more advanced production methods. Markets crowded by zombies limit the scope for other businesses to build up the financial resources that can allow them to innovate and expand in the future.

Zombie firms in the OECD area

Researchers have discovered that these trends in Japan now apply across many mature industrial economies, including Britain's. Muge Adalet McGowan, Dan Andrews and Valentine Millot have looked at how the zombie firms now surviving in many countries have repressed productivity performance.[11] Their study uses a quite restricted definition of zombie firms as firms 10 or more years old with an interest coverage ratio of less than one (in other words, the firm is reliant on cash reserves, selling assets or further borrowing to

survive) for three consecutive years. Others define zombies more widely as firms making persistent losses, or that are in persistent financial difficulties.

Whatever the definition of a zombie firm, the common theme is that a greater number of weak companies have been surviving, when in previous times they would have closed down – 'exited' the market.

Adalet McGowan, Andrews and Millot describe lower exit rates, declining business dynamism and wider productivity divergences. They explain that rising productivity dispersion would ordinarily imply stronger incentives for productive firms to aggressively expand and drive out less productive firms. But we are not in ordinary times. The authors underline how the productivity gap between frontier and laggard firms has risen, while the forces of dynamic adjustment have waned. High-productivity firms haven't expanded that much; fewer low-productivity firms have gone bust. [12]

The study's authors sum up the vicious circle like this: 'Besides limiting the expansion possibilities of healthy incumbent firms, market congestion generated by zombie firms can also exacerbate productivity dispersion, create barriers to entry and constrain the post-entry growth of young firms. Finally, we find that an increase in the capital stock sunk in zombie firms is associated with less productivity-enhancing capital reallocation, measured as the decline in the ability of more productive firms to attract capital.' [13]

The zombie phenomenon in Britain

Britain well expresses the West's shift to congested, zombie economies in which creative destruction is muted. In the mid-1970s and early 1980s, recessions in Britain played their traditional role of helping to clear out some of the weaker sectors and businesses.[14] By contrast, subsequent recessions, even the deep one following the 2008 financial crash, were much less destructive. Moreover, while there was visible 'destructive' de-industrialisation in the 1970s and early 1980s, Britain saw much less in the way of 'creative' re-industrialisation in subsequent years. Between the early 1980s and the years leading up to 2008, both business deaths and business births in Britain dropped by a quarter. Business deaths fell from about 13 per cent of active firms to about 10 per cent, while births decelerated from about 16 per cent to 12 per cent.[15]

Rates of corporate failure and startups have remained low, even during the recessions since the 1990s. In Britain after the 2008 financial crash a higher proportion of businesses than usual were unprofitable and making losses, but fewer went bust. As the Bank of England's Ben Broadbent described, firms were being kept in business, and retaining their employees, despite making relatively low returns.[16]

The headline figure of company liquidations remained lower in the recession following the financial crash than it had been in the early 1990s recession, despite the six per cent decline of GDP being about three times as deep. The annual rate of company liquidations

was 17,000 from 2009 to 2012, lower than the 21,000 liquidations experienced from 1991 to 1994.[17] The absence of a leap in business failures after 2008 occurred despite a post-crash jump in the number of loss-making firms, from about a quarter of businesses in the 1990s to more than a third since the crash.[18] More businesses were losing money, but fewer were closing down.

Andrew Haldane, chief economist at the Bank of England, has applied the OECD's insights into reduced productivity diffusion to assess the British experience. He reported that the UK picture broadly matched the same widening – he also calls it 'bifurcation' – of productivity distribution, with a small set of frontier firms whose productivity growth continues apace but a long tail of laggard firms whose productivity has effectively stagnated. Haldane's findings are consistent with those of the productivity review chaired by Sir Charlie Mayfield, chair of John Lewis Partnership. The review identified a lengthening tail of companies across all sectors in the UK where productivity performance was falling short.[19] It concluded that the diffusion of best practice productivity methods has been getting worse, noting that 'the lead of a few is being weighed down by the stagnation of the many'.

Firm-level analysis of a sample of 30,000 companies produced, in Haldane's words, several 'striking' features: 'First, it is clear that at least three-quarters of all firms in the sample have seen productivity flat-line over the past 15 years. There is a long tail of companies who have, at least in efficiency terms, stood still. Second, it is only firms in the upper echelons of the productivity distribution that have seen any growth and only those in the top 1% or above who have seen rapid growth. And this growth has been rapid, with the productivity of the top 1% of companies increasing by on average around 6% per year since 2002. These are the frontier firms. It is clear that, at the same time as the long tail of companies have been stagnating, they have been sky-rocketing. Or put differently, the distribution of UK firm-level performance has itself been widening or bifurcating over time.' [20]

Haldane admits he doesn't have answers to the question of what is preventing the diffusion of processes and technologies used in one firm to other firms operating in a similar region or sector. But finding these answers, he concludes, is 'key for unlocking the growth and productivity potential of the long tail of companies and hence of UK PLC'.[21] Haldane is correct. This is a fundamental matter for the government to address in developing its industrial strategy.

The widening of productivity divergences and the survival of many low productivity firms reveal that the blunting of creative destruction is a significant factor in Britain. The resulting congestion underpins low productivity growth and impairs the allocation of capital to more productive uses. Further analysis by Alina Barnett, Ben Broadbent, Adrian Chiu, Jeremy Franklin and Helen Miller suggests 'that frictions to the allocation of capital are likely to be one of the factors that can help to explain the persistent weakness of UK productivity'. [22]

The fact is that *failure to deal with the zombie economy will neutralise even the most pro-innovation measures included in the Green Paper. Support for more R&D will be less effective if the resources needed to make use of it are tied up in low-productivity businesses*.

In a study off the US experience, Daron Acemoglu, Ufuk Akcigit, Nicholas Bloom and William Kerr showed that industrial policy interventions such as R&D tax subsidies are only really effective when policymakers can ensure the exit of low-productivity incumbent firms. This is necessary to free up R&D resources, including skilled labour, for use by innovative incumbents and entrants.[23] The authors' conclusion is highly relevant to this consultation. The optimal industrial policy should be to encourage the exit of low-innovation firms, while supporting more R&D by high-innovation incumbents and startups.

To summarise, *sustained productivity growth requires having enough of business churn to complement the technological upgrading of existing firms. Too much of the Green Paper addresses the latter requirement, and not enough of it the former.*

That imbalance, indeed, could turn into an absolute liability. A zombie economy in which creative destruction is muted discourages all businesses from investing. *To the extent that a 'modern' industrial strategy remains stuck in the old pattern of sustaining zombie firms, it will, ironically, make the productivity situation worse.*

Public policy keeps zombie firms on life support

To some extent, the perpetuation of a low-productivity zombie economy is a spontaneous outcome of slower economic growth. The economic malaise has a self-reinforcing aspect to it. As noted already, the preponderance of zombie businesses clogs up the economy and holds back investment and productivity-enhancing innovation by viable firms, including by frontier companies.

But public policies have played a significant role here in keeping low-productivity businesses on life-support. This policy-induced aspect of productive weakness needs to be openly recognised, not simply on the grounds of honesty, but also because this is something an active industrial policy can seek to change. Policies with unhelpful, if unintended, consequences can be amended or revoked to reverse their productivity-impairing effects.

OECD studies on commercial competition, already mentioned, note that regulations *preventing or limiting firm entry and expansion* are particularly damaging for productivity and economic growth. Andrews, Criscuolo and Gal also found that public policy might partly be to blame for the productivity slowdown: the productivity gap between frontier and laggard firms was largest where regulation restricted competition and business dynamism. The authors suggest that, in OECD economies, the observed rise in multi-factor productivity divergence might at least partly be due to policy weakness 'stifling' the diffusion and adoption of innovation.[24]

Existing policy measures can act to reinforce the zombie economy. Adalet McGowan and Andrews have studied how, in Britain and elsewhere, *changes to insolvency regimes have tended to favour company rescue over company liquidation*. This has been the direction of change for Britain's insolvency regime since the late 1980s, not least in the 2002 Enterprise Act. This shift has the obvious advantage of reducing disruption and job losses in the short term, but at the potential expense of prolonging the life of non-viable insolvent firms and curbing creative destruction.[25] When this results in low exit rates, average productivity falls further as growth opportunities for more productive firms are crowded out. The short and long-term prospects for productivity growth are both curtailed.

In their broader analysis of zombie firms, Adalet McGowan, Andrews and Millot suggest that problems of lower exit rates 'are likely symptomatic of structural policy weaknesses, particularly with respect to insolvency regimes'. Business rate revisions can fall into the same category by often penalising businesses that are seeking to invest and upscale while protecting those that may be struggling in areas that have performed less well.[26] The authors continue that 'there are reasons to suspect that non-viable firms may also be increasingly kept alive by the legacy of the financial crisis, with bank forbearance, prolonged monetary stimulus and the persistence of crisis-induced SME support policy initiatives emerging as possible culprits'.[27]

Measures of financial stabilisation can have the unintended consequence of holding back creative destruction. The easy monetary policies introduced in emergency circumstances from 2009 helped keep credit markets from freezing up, which could have had grave economic consequences. However, eight years later, these policies, now simply part of the furniture, merely featherbed weak businesses. At just 0.25 per cent, Bank Rate has never been this low in the 300-year-plus history of the Bank of England. Before 2009, the lowest Bank Rate had been set at two per cent, operating during most of the 1930s and 1940s.[28] Rates at today's ultra-low levels have proved a lifeline for many struggling businesses since the crash. But they have also failed to breathe life into firms that should have been declared dead a long time ago.

Fathom Consulting has highlighted the consequent role of ultra-easy monetary policies for damaging productivity growth. It explains how low central bank interest rates suppress the forces of creative destruction, resulting in the creeping 'zombification' of the corporate and banking sectors.[29] Not only do low-productivity firms hold out because of lower interest payments, but very loose monetary policy also encourages *bank forbearance*. Banks have less reason to recognise losses on non-performing loans.[30]

Adalet McGowan, Andrews and Millot usefully explain how well-meaning policies can later rebound on governments. They conclude that 'some crisis-induced policy initiatives such as government loan guarantees and low interest rates might have been useful in facilitating credit and preventing firm exit that would lead to mass layoffs. However, given the length of the crisis, the persistence of some of these policies may now be detrimental to productivity growth by distorting credit supply, especially given asymmetric information

problems making it difficult to identify unviable firms, and curbing the potentially positive contribution of exit.'[31]

The policy dimension to the collapse of creative destruction also applies to the unintended effect of policies introduced to meet goals other than economic stabilisation. This includes, for example, welfare measures such as Working Tax Credits. These were meant to encourage people to work, rather than rely on out-of-work benefits. Instead, they have often simply subsidised wages in low-productivity jobs, thereby helping to sustain some zombie businesses.[32]

Often with the best of intentions, government policies have buttressed the low-productivity features of the British economy. What once supported existing businesses now act as barriers to innovative business spending. Regulations, government spending and state procurement policies, changes to insolvency rules, easier monetary policies: all these have shored up incumbent businesses, many of which are low productivity, and have conserved the economy as it is. As a result, flatlining has taken precedence over the disruption necessary to ensure sustained productivity growth.

Debating a new idea

An *effective* industrial strategy, in the sense of one that revives productivity growth, is one that shakes the economy up, not preserves it. Economic renewal necessitates closing down low-productivity, low-profit or loss-making businesses to make way for new sectors and new businesses. Andrews, Criscuolo and Gal argue that a 'key implication' of their analysis is that weak productivity performance in OECD countries may persist, 'unless a new wave of structural reforms can revive a broken diffusion machine'. [33] Such structural reforms should be the primary goal of any new industrial strategy.

On the other hand, a set of industrial policies that acts to mollycoddle existing businesses and the status quo economy is worse than doing nothing. It blocks the forces of creative destruction and, by postponing the day of reckoning, can only make it so much worse when, as is inevitable, it arrives.

This 'alternative' to creative destruction doesn't at all prove the old mantra that 'stability is sexy'. By inhibiting productivity growth, this kind of stability in fact spells disaster.

The discussion initiated by the Green Paper about developing a modern and effective industrial strategy provides an opportunity for the government to popularise a new idea. The idea is simple: saving the existing economy is not only futile, but also a barrier to durable prosperity. Britain hears a lot about technological 'disruption' from its friends in Silicon Valley. Equally, an industrial strategy of economic disruption is necessary to lay the foundation for a twenty-first century industrial revolution.

Recasting industrial strategy to enable creative destruction to operate again will not be a painless affair. A national public conversation is necessary to explore why such a new

course of policy is needed for economic renewal. Such a nationwide debate is a precondition for securing popular understanding and support, and a mandate for this direction of change.

Jobs: preparing transitional measures

The closure of zombie firms will lead initially to redundancies. As already stated, a new, recast industrial strategy will thus need to include transitional devices related to employment: financial, training and other measures to sponsor workers and their families through the move from existing employment, or unemployment, into the better, differently skilled jobs of the future. The additional tax revenues generated by the more productive, higher-employment economy that results from these policy changes would more than cover the additional costs to the Treasury.

As Adalet McGowan, Andrews and Millot explain, it is reasonable to expect that, over time, the costs arising from looking after displaced workers will be mitigated by two factors: 'First, the removal of the zombie congestion implies higher non-zombie employment growth, especially amongst young firms which disproportionately contribute to aggregate job creation…. Second, the exit of zombie firms creates scope for some displaced workers to be reallocated to a job that better matches their skill, which is significant given evidence that highly-skilled labour is trapped in relatively low productivity firms in many OECD countries…. A better matching of skills to jobs makes workers more productive, implying scope for higher wages, and reduces the risk that under-utilised skills will quickly depreciate.'[34]

Bite the bullet: four components of firm but fruitful industrial strategy

1. Review existing economic policies

Existing economic policies need a searching review. They should be modified or rescinded if they interrupt the process of creative destruction. This includes taxation policies, state spending and procurement policies, monetary policies, competition policies, and insolvency legislation.

For example, monetary policies need to be moved quickly out of 'emergency' mode. Official interest rates should be raised speedily, if gently, from the current ultra-low levels to about two per cent in the first instance. These steps will require an end to the formal independence provisions of the Bank of England.

2. Review EU and EU-related business regulations

Britain needs a review of all existing economic regulations, again from the perspective of modifying or rescinding them if they interrupt the process of creative destruction, or otherwise inhibit innovation. This requirement could be included as part of the Great Repeal Bill and start with a review of all EU regulations and of British laws and regulations created to implement Britain's obligations under EU Directives. A review of other national regulations could follow, using the lessons learnt during this exercise.

3. Recast the proposals in the Green Paper

The existing proposals for industrial policy contained within the Green Paper need to be recast from the framework of encouraging a dynamic of continuous change to replace the zombification of recent decades. Whatever their original goals, all Green Paper policy measures need to be assessed for their possibly unintended effects – sustaining existing low-productivity businesses at the cost of hindering the entry or expansion of more productive ones.

For example, the Green Paper includes the commitment to ensure that all major government procurement projects are structured in a way that supports productivity improvements (p 73). This is a worthy objective. The Green Paper notes that at least some of public procurement procedures remain too complex. The current system continues to privilege larger incumbents at the expense of smaller companies and recent startups.

The current target is to ensure that a third of the UK's total public procurement spend goes to small businesses by 2020 (p 73). This target should be revised to favour *innovating companies, young and old, small and large*. The definition of such companies can be based on a combination of objective and subjective factors – age of business; level of R&D spending; net business investment; approaches to transforming production processes or the delivery of services.

4. Transitional measures: help for workers during economic upheaval

Britain needs coherent policies to cover the costs of workers' displacement and provide wider support to them and their families during the transition to new employment.

These workers will likely require specific training sponsorship for their future jobs. Training unemployed people is, however, no panacea. What matters most is encouraging the investment needed to create new industries and jobs. This should be complemented by assistance with job searching, possible help with relocation, and re-skilling for these new jobs.

It is pointless and counter-productive to train people in skills for roles that might no longer exist. For example, training people today in how to code particular software might sound future-proof. However, current coding methods might be passé in five or ten years. It is important that today's training emphasises foundation skills and capabilities to facilitate future flexibility and adaptability for the work tasks and activities to come.

Employers are best placed to provide this training in the skills required for the new jobs. Whether for apprenticeships or other work-based qualifications, only employers have the knowledge, technical means and incentives to provide the job specific knowledge-based training the economy will need.[35] The costs can be shared between the company and public spending.

The extra cost to the government for these transitional human arrangements will in time be financed out of the tax revenues arising from the extra productivity, employment and economic growth that the new policies will generate.

Conclusion

In the foreword to the Green Paper, Greg Clark notes that, too often, industrial strategies have become 'strategies of incumbency'. Existing firms and industries were propped up at the expense of new and growing ones. Later the Green Paper presciently warned against the government unwittingly creating such a strategy of incumbency (p 98).

The test for this government's industrial strategy is not just to avoid this fate but also to be pro-active to reverse the unwitting effects of years of pro-stability public policies. This is how Britain's economic renaissance can begin.

About the author

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SECTION TWO

Where to back labs, prototypes and designs

James Woudhuysen

The question responded to:

5. What should be the priority areas for science, research and innovation investment?

Introduction: new sectors of production, 2030

Britain needs not just new products, processes and services, nor even just new methods of corporate innovation, but also whole new sectors of production. In our view, the priority areas for investment in science, research and innovation should prepare the way for these new sectors.

A cursory glance at the British economy in the 1930s reveals one of the characteristic features of that decade – the growth of new industries. Around the Midlands and the South East, sectors such as aircraft, chemicals, electrical engineering, synthetic fibres, printing, paper and publishing, cars, household appliances and furniture had a relatively good Depression.

While their overall benefit to the British economy in the 1930s has to be set against what was achieved through a revival of housebuilding, the performance of the new industries stood in some contrast with old industries located elsewhere: coal, shipbuilding, iron, steel, cotton and wool.[36] The new industries were competitive and created employment. Moreover, after many vicissitudes, they are still around today, even if some of them (fibres, radios, household appliances) have been reduced in status.

The years to 2030 will be nothing like the 1930s. However, with the exception of cybersecurity, there are few very obvious candidates for new sectors of production today. In part, that's because the very novelty of such sectors makes them hard to forecast. In part, too, there is always a problem defining what is really new about a new sector. Last, forming a new sector of *production* is not quite the same as deciding on priority areas for investment in *science, research and innovation*.

It is important to get the balance right here. Basic, blue-skies research is utterly indispensable, even if governments have for too long been sceptical about it.[37] Basic, blue-skies research has, historically, led to very practical technological advance, as is shown by the case of John Tyndall, who worked out why the sky is blue.[38] However, basic research has no direct connection with the new sectors that eventually it helps bring about. And yet: *by thinking carefully about new sectors of production, we can hope to gain some important clues about the kind of research and development (R&D) and innovation the government should be backing*.

A note about basic research

The spin-off from basic research cannot easily be predicted, but it can safely be said that nothing is as practical as a good theory. The Green Paper says that the Government 'has protected the Government spend on basic science, in recognition of its central role in generating new knowledge and breakthrough discoveries'. Yet in fact the chart displayed on p27 shows that, in terms of the composition of R&D in different countries, Britain is among those that devote the least part of their R&D budgets to basic research. The Government needs, urgently and dramatically, to increase the budget for basic research, not just protect it.

The Green Paper usefully describes technologies which the Government's new Industrial Strategy Challenge Fund could support (p15). These include smart and clean energy technologies (such as storage and demand-response grid technologies); robotics and artificial intelligence (including connected and autonomous vehicles and drones); satellites and space technologies; leading-edge healthcare and medicine; manufacturing processes and materials of the future; biotechnology and synthetic biology; quantum technologies, and transformative digital technologies including supercomputing, advanced modeling, and 5G mobile networks. The Green Paper also reminds us (p16): 'Given its central importance to a range of new technologies, including in the automotive sector, the government has also asked Sir Mark Walport, the Government's Chief Scientific Adviser, to consider the case for a new research institution as a focal point for work on battery technology, energy storage and grid technology. Sir Mark will report in early 2017.'

We have no quarrel with any of this. All the technologies discussed are highly relevant to the transformation that the British economy now needs to make. However, this is a supply-side list of technologies that already exist, not a demand-side enquiry into the kind of production sectors that might give the biggest lead to British science, research and innovation.

To that enquiry we now turn. The reader should understand that the sectors proposed for further consideration are proposed tentatively. The UK is at the very start of what should be a national debate over the worthiest sectors to lead British innovation. The debate, like scientific research itself, must always be open ended. The rest of this paper, then, is by its nature speculative. Changes will be made to candidate sectors as new developments occur. The treatment here is important not so much because the sectors discussed will always be the right ones, but because the thinking that led to them may prove useful when doing a more formal and more public appraisal in the future.

What criteria should we apply in deciding on new sectors?

To represent innovation as merely a combination of old approaches is to do the cause of the new an injustice.[39] But a dynamic new sector *can* be an ingenious synthesis of old ones. All that needs to be remembered here is that sectors such as optoelectronics – which mixes light with electronics – have been around a long time. In the domain of research rather than full-scale production, indeed, the forecaster Herman Kahn used to refer to the potential of the 'hyphenated sciences' (bio-physics, bio-electronics) more than 30 years ago.[40] So in any future exercise of the sort we engage in here, we advise looking at new combinations of old sectors with a cold eye.

With that simple proviso, by what criteria might it be reasonable to judge new sectors of production that could benefit from government backing for high technology? To its credit, the Green Paper, almost in passing, mentions three of the most important criteria in its opening chapter, 'Investing in science, research and innovation'. It says that Britain must *embrace innovation* 'to keep ahead of the competition, create more good jobs, and make sure jobs in the UK are secure'.

These exacting criteria should be applied when considering how to prepare for new sectors of production.

New sectors need to be *competitive*, in that they can compete on the world market, add to exports, and cannot easily be usurped by low-cost overseas producers. They need to be high-tech, basing themselves on advanced processes and IT. Their productivity needs to be high.

New sectors, however, also need to create a lot of good, highly paid, motivating *jobs*. And to reconcile this criterion with the first is to square a pretty difficult circle. But it can be done. The British car industry, for instance, boasts both relatively high productivity and a lot of primary and secondary jobs.

The third criterion hinted at by the Green Paper pertains to the *durability* of jobs. The potential new sectors that should be born in mind when planning public investment in science, research and innovation need to stand the test of time. The emergence of a new sector will not happen overnight; but provided one can be said to have emerged by 2030,

we can then demand that it stay the course till 2050. Durability, then, means that a new sector has a lifespan of at least 20 years.

To these three criteria could be added two others. New sectors of production should ideally meet real areas of consumer, business or government demand. At the same time, they should ideally foster the development of *new skills*.

Some possible candidates for new sectors

Synthetic biology

In the field of genomics, synthetic biology applies the principles of electronic and chemical engineering to the design, construction and characterisation of biological systems from traditional genetic engineering research.[41] It can help replace existing fine chemicals and develop superior ones, including fuels, flavours and fragrances.[42] Mammalian synthetic biology can assist in disease diagnosis, screening for pharmaceutical compounds to combat diseases, screening for and manufacturing vaccines, and in gene therapy, cell therapy, immunotherapy, and therapies for cancers and infectious diseases.[43]

It is an attractive field with a multiple of applications. Worryingly, though, the global market for it is variously estimated at $38.7bn in 2020, based on a compound annual growth rate (CAGR) of 46.4 per cent from 2014 onward [44], but, also, at only $5.6bn in 2024, based on a CAGR of 24 per cent from 2013 onward.[45] Moreover, the pioneering development of semi-synthetic artemisinin, an antimalarial drug, took nearly 10 years.[46] Similarly, a team of 20 led by Craig Venter, the *bête noir* of US biology, took more than 10 years and $40m to synthesise a bacterial chromosome and put it in a bacterium so as to replace the bacterium's DNA.

Breakthroughs in synthetic biology, then, require tenacity, and there is nothing wrong with that. Yet while the size of demand for synthetic biology may turn out large and long lasting, projects in it will likely involve only a small scientific workforce. Synthetic biology is a high-tech affair, but does not qualify as a major, employment-creating new sector.

Electronic clothes

In a synthesis of semiconductors and textiles, clothes could be hardwearing but supple and washable electronic interfaces and displays. Perhaps given the ability to clean themselves, electronic clothes could be hooked up to sensors, medical apps and energy devices to make them comfortable companions to the human body, sought after for snowstorms as much as for sweaty buses.

A more serious approach to wearable media than has so far been the case could, if more consciously linked to British fashion and to fashion retailing, usher in a new industry. Fully realised, electronic clothes could go beyond sports and fitness apparel and medical applications, and therefore extend beyond what has been estimated as a global market of

$3bn by 2026.[47] Producing electronic garments would also likely be a highly automated business, reliant on impressive budgets for R&D and for design.

However, the durable employment benefits of electronic clothes are more apparent in the Indian subcontinent, where textiles still form a major source of jobs, than in Britain. On this count, electronic clothes might well be a fashion industry initiative that government sponsors, but would not meet the exacting criteria we have laid out for viable new sectors in the UK.

Pharmacogenomics

Again in the field of genomics, pharmacogenomics – choosing and dosing prescription drugs according to a person's genomic variants – has particular promise. Research by Ramy Arnaout and others suggests that it could cut down, for instance, the $80bn that ineffective drug treatments, or adverse side effects, cost the US each year.[48] However, as Arnaout and his colleagues model it, just to draw up guidelines for the effective use of pharmacogenomics over six prescription drugs, plus the statin class of anti-cholesterols, could take 20 years, even if the exercise would likely cost no more than $6bn.

Arnaout and others did not compute the likely cost of implementing pharmacogenetic treatments in the US. Their study covered drugs such as warfarin, as well as the nicotine-replacement patch. It is suggestive not so much of a whole new, job-creating industry, but of an important, still medium- to long-term revision of drug treatments from one-size-fits-all 'population' medicine to the personalised sort. After all, one estimate gives the global market for pharmacogenomics as a modest $12bn in 2024, based on a CAGR of 5.7 per cent from 2016 onward.[49]

Pharmacogenomics is a high-tech domain that is likely to be in demand from consumers and government for many years. It will certainly help create fresh scientific talents. But though pharmacogenomics is an important area for government research, and though it might eventually save the NHS a lot of money, it doesn't qualify as a durable, job-creating new sector capable of making more than a minor difference to the British economy.

Some stronger candidates for new sectors

Mass-manufactured housing

In China in 2015, the company Broad Sustainable Building assembled a 57-storey, 800-apartment high-rise block, complete with 20cm of insulation, quadruple-glazed windows and reputedly the best air quality in China.[50] The time taken to complete this feat? Just 19 days, using prefabrication techniques.[51]

In Britain, Legal & General (L&G) has also shown the potential of mass-manufactured housing. Its new factory in Yorkshire is set to turn out 3,500-4,000 homes a year, each installable within a single working day and with exteriors specified by the homeowner.[52]

Made of cross-laminated timber, L&G claims that kitchens, bathrooms, doors, ironmongery, painting and even carpets can all be done in the factory and certified as free of defects.

This is a fine start, but the overall output planned for manufactured homes in the UK is still very small – even an estimate that it accounted for seven per cent of UK house-building by value in 2015 (against up to 15 per cent in Germany and Japan) seems over-optimistic.[53] The Government itself has set a target of one million homes built anew – or converted from non-residential buildings – for England by 2020.[54] But the demand for new homes in the UK is very much higher than this, and conversion from non-residential buildings may prove more difficult than it seems.

To refresh the installed base of British housing means building no fewer than 500,000 new homes a year.[55] At this scale, government intervention to support and extend the efforts of companies such as L&G is more than justified. A serious R&D programme around house manufacturing would mean that the technology now available could be improved. A great number of rain-free jobs could be created, even if on-site work still persists. Output would need to stay at high levels for decades for Britain's housing stock to be truly modernised. Importantly, cheaper, better, upgradable manufactured homes would not only be competitive with conventional ones: they would put money in workers' pockets – especially the pockets of first-time buyers. Done right, they could raise community morale.

The precondition for installing millions of homes needs stating baldly: the Green Belt needs to be built on and the land deregulated. If this is done, and if Government can issue Type Approvals for particular (customisable) house designs, then house manufacturers will at last face a dependable, large-scale market, so bringing costs down.

Clever pipes

All kinds of process engineering, along with on-shore and offshore energy production, utilities, infrastructure and construction, rely on pipes. In new housing, automated waste collection systems, often relying on pneumatic power, have spread from Europe and Asia to Australia.[56] These are based on pipes. Especially in dry parts of the world, pipes are vital to agriculture. But today's pipes are often characterised by leaks and poor interfaces (pipe-to-pipe, pipe-to-human). Laying pipes, mapping them and digging them up are a hassle.

A step-change in pipe manufacture, safety and tracking could open important export markets for Britain, on top of domestic demand. Led by companies such as Durapipe and Polypipe, this is currently a rather low-tech business that nevertheless has important responsibilities in relation to health, the environment and flooding.

It would be idle to pretend that pipes will generate hundreds of thousands of jobs: they may only be able perhaps to create 10,000-20,000. Yet, equipped with sensors and the data analytics to support predictive maintenance, the pipes of tomorrow won't need the dubious adjective 'smart' to commend them to business. From sub-sea pipes to pipes for broadband,

British business has a great need for pipes, while the country's existing pipe-makers would undoubtedly benefit from an orientation toward sensors and the Industrial Internet of Things.

Between pharmaceuticals, medical devices and digital health [57]

Nowadays, pharmaceuticals are dispensed, and diagnoses assisted, by all kinds of sophisticated medical devices, whether attached to or puncturing the skin, used to inhale, or inserted inside the body. Like these devices, pills are also being equipped with sensors, while prosthetic fittings are becoming more movable, like parts of an exoskeleton.

The opportunity here is for the Government to support research that fuses Britain's traditional excellence in pharmaceuticals with its medical devices and IT sectors. Medical device makers in the UK are strong in orthopaedics, imaging, diagnostics and cardiovascular systems. Though it is true that many are foreign owned, these products already provide jobs for perhaps 50,000 people. Meanwhile, one analysis has the global market for medical plastics alone as worth £17bn in 2021, based on a CAGR of 6.2 per cent from 2016 onward.[58] Government backing to increase R&D in medical devices, link it to developments in drug discovery and IT and make UK efforts much more ambitious could perhaps double the number of jobs in this arena.

Given pressures on the NHS, the weighty significance now attached to patient adherence to medical regimens and the trend toward e-health in the home, the demand for medical devices is out there. In terms of the new skills called forth by the consolidation of such a sector, medical devices now drive innovations in sensors. [59]

Toward a New Carbon Infrastructure [60]

Despite the bad press it gets, carbon is in fact a miracle element. It is prominent in cars, flexible and printed electronics, nanotubes, construction, catalysts, healthcare, the chemical industry, artificial fuels, manned space exploration, carbon capture and storage from power plants (CCS) and the capture of CO_2 from the air.

To give one example of carbon's potential: in the case of CCS, researchers at the University of California, Los Angeles, hope to convert power station emissions into a new kind of concrete that can replace cement.[61] Here is a material whose many applications mean that it still deserves a lot of basic research. At the same time, a UK move from research to commercialisation is vital. For all the money government has put into R&D in carbon-based graphene in particular, few obvious results are apparent.

Recycling carbon on a significant scale, and taking advantage of all the opportunities around it, would lead to the development of a whole new sector. Britain urgently needs to drop its obsessions with minimising carbon footprints, and start maximising the benefits of carbon.

Service robots for older people

In 2015, the world market for every kind of professional service robot was just 41,000 units; these kinds of machines were in aggregate worth less than $5bn.[62] Yet there is a world to play for in service robots.

Britain's crisis in the care of older people, and the opening that Brexit brings to forge links with relevant robot specialists in Japan, supply two reasons why we can and should expect medical and care workers to work more and more alongside robots in years to come. Of course, a survey in 2012 found that, of more than 25,000 people questioned in the European Union, 60 per cent thought robots that care for children, the elderly and the disabled should be banned outright; and 86 per cent said they would be uncomfortable with one caring for their children or parents. However, many more were relaxed about robotic assistants and surgeons.[63] There are also some tasks, particularly around personal hygiene, that people may prefer robots to perform rather than humans.

Good research on service robots for older people could jump-start a remarkable new sector, very much fitted for UK demographic trends in decades to come.

Labs, prototypes and designs

In its urge to close the gap between brilliant UK boffins and market commercialisation, the Green Paper says (p26) 'it is striking that in leading innovation nations, such as Israel and countries in Asia, a greater proportion of total R&D investment is on later-stage, experimental development. China, for example, currently spends twice the share of the UK. This may amplify the industrial impact of such countries' funding commitments to R&D.'

We find the argument here weak, and the examples of Israel and China unconvincing as a prospectus, for Britain, on the right balance between basic and applied research. However, we very much favour, in all the 'stronger' candidate new sectors we have proposed, lab-work being complemented by early prototypes and design mock-ups.

It makes sense to issue a first-draft description of product features, advantages and benefits early, so that it can be criticised early, and so that critics can take responsibility for changes.[64] Then, it's wise to use 'agile' design processes borrowed from agile software development. Instead of the design team on an innovation project presenting management, in dangerous style, with a fully-finished item as a kind of *fait accompli*, the emphasis should be on communicating often, within the team, with management and with users, throughout the project – rapidly making a series of rough-and-ready prototypes to prompt discussion, and refining those prototypes iteratively.[65]

As a postscript to this paper's treatment of new sectors, then, we would uphold government support for *enabling technologies* in this domain. Such support would aid the commercialisation of innovation.

Relevant enabling technologies here include: lab equipment, digital design modeling and 3D printing. These do not make up a sector in their own right, but should certainly be foregrounded in government programmes aimed at aiding R&D.

Conclusion

The Green Paper's discussion, in Chapter 8, of the need for Britain to cultivate world-leading sectors has merit. Indeed, while we find the statement that the Government's Sector Deals are 'not about the Government providing additional funding' (p100) something of a cop-out, we agree that such deals should not be 'confined to existing or traditional industrial sectors' (p102).

The new sectors this paper has highlighted are certainly not confined in this way. All five of them, and most obviously service robots, will rely on research in IT; among them, only the convergence of pharmaceutical, medical devices and digital health has the slight demerit of combining existing sectors. All five new sectors are germinal enough, too, to benefit from the Challenger Business Programme, particularly given that, as the Green Paper observes (p103), this programme may help overcome the regulatory issues that often affect new sectors.

These new sectors, as we have said, are for debate. The basic and applied research, development and design that they could inspire, along with the relevant institutions and funding mechanisms that could suit best, cannot naively be mapped backwards from them. Experts in the political economy of R&D, in science, engineering, sociology, business finance and design must all be drawn in to the work of deciding the kind of programmes of R&D new sectors make necessary. The general public deserves a full hearing here, too.

But make no mistake. Homes, pipework, medicine based on digital devices, the multiple applications of carbon: these are, like 'carebots', sectors founded on major problems that need solving. They, or other new sectors like them, give Britain a chance truly to strike out on a new path – one that will not just raise productivity and employment, but also inject the economy and the population with a new, risk-taking spirit of adventure.

About the author

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SECTION THREE

Time for cheap, reliable energy

Andy Shaw

The questions responded to:

27. What are the most important steps the Government should take to limit energy costs over the long-term?

28. How can we move towards a position in which energy is supplied by competitive markets without the requirement for on-going subsidy?

Introduction: a moment to focus on essentials

Cheap, reliable energy is a foundation for economic growth and prosperity. The government has the opportunity to build a popular mandate for a new approach. Energy costs should not be 'limited', but dramatically reduced (Question 27). The approach outlined in this paper also eradicates the need for subsidies (Question 28).

Theresa May's foreword to the Green Paper states: 'Last summer's referendum was not simply a vote to leave the European Union, it was an instruction to the Government to change the way our country works – and the people for whom it works – forever.'

The Prime Minister is right. Her statement can be applied to energy policy, where a bold change in direction and a clear focus is required. Energy costs could perhaps be halved within seven years.

Set a public target to win a mandate

Setting a public target of halving the cost of gas and electricity would be a bold, yet achievable aim. The government could show that it has an industrial strategy for energy which supports the development of new sectors of production and directly benefits householders. Lower gas and electricity bills will especially help ordinary working families on tight budgets.

Resolving the well-known energy 'trilemma' – the task of simultaneously meeting climate change targets, guaranteeing security of supply and minimising energy costs – has proved impossible. An emphasis on decarbonising energy production predominates, while energy costs are artificially inflated.

Years of UK green energy policy have had a minimal effect on worldwide CO_2 emissions. The impacts upon the world's climate of all COP 21's promised 'Intended Nationally Determined Contributions' look like they will turn out to be minuscule. According to Bjørn Lomborg, if every participating nation met every pledge by 2030 (something that is far from guaranteed), the total reduction in the planet's temperature will likely only be 0.17 degrees Celsius… by 2100.[66]

As Greg Clark states in the Green Paper, 'nearly 10 years on from the Climate Change Act, that framework requires updating'.

One widely publicised if controversial estimate of the cost of implementing the 2008 Climate Change Act in the UK is £300 billion between 2014 and 2030. [67] Whatever the true figure, we need to ask ourselves if this is the right way to spend such a significant sum. Is there really public enthusiasm for this project? Does it support or hinder industrial renewal?

Ultimately, a decision has to be taken on whether energy policy should support the plan to decarbonise energy production now, and so undermine the British economy, or whether to focus instead on price reduction and improved reliability of supply.

As Greg Clark states, 'Leaving the European Union allows – and requires – us to make long-term decisions about our economic future.' Energy is a vital part of what now needs to be decided upon.

Why energy policy is crucial

From baby incubators to crematoria, energy is vital to modern society. Rising productivity means a greater reliance on energy, since machines amplify our physical and mental work.

Reducing the cost of energy enables society to focus resources and efforts toward other areas of economic and social life. The government's industrial strategy should include the aim of continuously driving down the cost of energy in the short, medium and long term.

Firstly, a reduction in the cost of industrial electricity enables businesses to reduce the cost of their products and services and so increase profits for further investment. This could help create jobs.

The Green Paper notes that industries that rely on heat and electricity are particularly sensitive to energy costs. As Karl Koehler, the chief executive of Tata Steel Europe, said in March 2016: 'Energy is one of our largest costs and we are disadvantaged by the UK's cripplingly high electricity costs.' As steel production has become increasingly mechanised, the cost of labour has become less important and the cost of energy more so. And when prices decline, as they did worldwide in 2016, energy costs loom even larger. In a report by the Committee on Climate Change, published in March 2017, overall costs for energy-intensive companies would be 5.9 per cent than otherwise by 2030 purely due to low-carbon policies.[68]

Cuts to the cost of the energy needed to produce cement, bricks and steel will flow through to infrastructure projects such as HS2, HS3 and airport expansion, as well as to housebuilding. Reducing electricity costs for train operators will enable faster repayment of loans, and lower fares. Vehicle production and robotics will also benefit.

On top of energy demand from heavy industry, infrastructure and rail services, IT operations in Britain require more and more electricity. The rapid growth of information-based services has driven the growth of data centres. Energy typically accounts for between 25 and 60 per cent of the running costs of one of these data centres; in 2016, data centres in the UK consumed an estimated 2-3 TWh per year of electricity – only about one per cent of overall UK electricity consumption, but a growing and very critical portion of it.[69]

Secondly, depressing the costs of household expenditure on gas and electricity enables individuals to spend income on other goods and services. The effect of reduced energy costs disproportionately benefits families on lower incomes, who spend a sizable part of their pay on utilities.

Additional income from cheaper energy will tend to be spent, rather than saved – something which would add a welcome boost to the economy. By contrast, subsidies for decarbonisation can only add to household energy bills, suppressing wider consumer expenditure.

The problems with wind and biomass

Britain's most buoyant renewable technologies are wind and biomass. Both energy sources require continuous subsidy and act as a drain on resources.

Current energy policy is self-destructive and self-defeating. It simply diverts resources from government, consumers and industry to prop up green energy schemes with no tangible effect on CO_2 emissions.

Wind power: the hidden costs

More than 7,000 wind turbines are now spread across the UK countryside and offshore. They produce about eight per cent of Britain's electricity. Throughout Europe there are 42,000 wind turbines. For the EU to hit its climate targets, it would need to install a total of 500,000 wind turbines. If the UK were to pull its weight in this enterprise, an area equivalent to the size of Wales would be forested with turbines.

Too many people imagine that wind farms are a one-off investment, which go on to produce energy for free and forever. However, to compensate for wind's intermittency, electricity must somehow be generated when the wind isn't blowing at the right strength. Every wind farm thus must be linked to a more-or-less equivalent gas power station or other reliable power source as back-up; so, as new wind farms are built, large extra investments are required. Wind turbines only operate to 20 to 30 per cent of their formal capacity. Thus, to the cost of introducing intermittent wind farms – initial build, maintenance, connection to the national grid, disposal after a relatively short lifetime of 20 years – is added considerable and often unacknowledged extra cost. Indeed, apart from back-up power, further additional costs are incurred because of the complexity of managing a continuously interrupted supply such as wind.

BEIS has estimated the costs of different power sources, before the addition of carbon costs, for projects starting in 2020:[70]

Technology	**Levelised cost before carbon costs per MWh**	**Levelised cost after carbon costs per MWh**
Combined cycle gas turbine	£47	£66
Onshore wind (>5MW)	£63	£63
Biomass conversion	£87	£87
Offshore wind	£106	£106

As can be seen from the costs of wind and biomass against those of gas, carbon policies make a considerable difference to relative costs.

Biomass: a complicated charade

Coal-fired power stations are continuing to convert from coal to biomass. Take Drax power station, in Yorkshire, which alone produces no less than eight per cent of the UK's electricity. Drax has six power units: two have been converted to biomass, while a subsidy has been agreed to convert a third unit to the same fuel source.

Britain's Carbon Tax artificially inflates the price of coal to make biomass cheap by comparison. In the UK, the Carbon Tax is currently £23.38 per tonne of CO_2 emitted (the figure for the EU is much more modest: £5.30). This tax makes it cheaper for Drax to import biomass, in the form of wood chips from the US and Canada, than to rely on coal.

The drive to convert coal to biomass has unintended consequences. Although biomass is classed as carbon-neutral, as an energy source it produces twice as many CO_2 emissions as gas. The CO_2 emissions in producing and transporting the fuel in the first place are also considerable. Trees are felled in Canada and the US and must be machined into wood pellets. These are transported to docks, shipped across the Atlantic to Liverpool and loaded on to specially-made rail wagons to be transported to Yorkshire. Diesel fuel powers the required forestry machinery, the trains and container ships.

A report for Chatham House published in February 2017 argues that 'while some instances of biomass energy use may result in lower life-cycle emissions than fossil fuels, in most circumstances, comparing technologies of similar ages, the use of woody biomass for energy will release higher levels of emissions than coal and considerably higher levels than gas'.[71]

In 2016, Drax produced two-thirds of the UK's biomass power. The official Contracts for Difference scheme guarantees the price for biomass-based electricity at £110 per MWh – like wind-based electricity, much more than the typical price for wholesale electricity in the UK. For example, for December 2016, Energy UK estimates the average daily price for power was £45.38 per MWh.[72]

How to achieve a successful energy policy

The Government's aim should not be to 'limit' energy costs (as stated in question 27), but to dramatically cut them.

If this strategy is vigorously pursued, while simultaneously investing in R&D for new energy sources, Britain can hope to address the longer-term challenges around energy. The following steps would from a good start:

1 Do a comprehensive review of the Climate Change Act

When the Climate Change Act was passed, the costs and implications were not fully understood, and were certainly not widely debated. There was no engagement with the public on the bill for implementation.

Years later, we have a better understanding of costs. In 2015, the Committee on Climate Change estimated costs running into billions per year – and now that carbon capture and storage is effectively a dead duck in the UK, those costs could double.[73]

Detailed research should be carried out to identify, as far as is possible the full cost of the various subsidies, taxes, levies and market manipulations implemented to support the Climate Change Act. The research should be made public to inform debate.

Regardless of the precise figures, policies designed to implement the Climate Change Act inflate energy prices at an increasing rate. This acts as a brake on the economy and reduces household incomes. Further, the focus on a range of complex initiatives to tackle CO_2 emissions diverts the civil service, universities and business planners towards a project that brings little benefit.

2 Increase spending on R&D

As a nation, we have to ask: should billions be spent on presenting Britain, a very minor carbon emitter, as a virtuous example which the world cannot help but notice and try to emulate? Or should Britain rather invest in new energy technologies which offer the chance to transform the productivity of the economy, create value and add wealth?

Until fairly recently, the history of world energy production moved in one direction. Mankind moved from wood to coal to oil to nuclear. Each discovery and innovation enabled us to create more energy from fewer resources.

The relatively recent fashion for 'green' energy has reversed this historic trend. Consequently, the usual benefits of economies of scale are not realised. In Germany, the expansion of wind power has created grid instability and significant increases in cost. No fewer than 26 German power stations are now running at a loss and it is foreseeable that the entire energy sector will be nationalised in the near future to keep the lights on.[74]

In April 1932 John Cockcroft and Ernest Walton split the atom for the first time, at the Cavendish Laboratory in Cambridge. In 1945, the most powerful energy source ever invented was publicly displayed in the atomic bomb. If a level of commitment similar to the Manhattan Project were devoted to researching and developing new energy technologies, humanity could dramatically reduce the cost of energy in the medium and long-term. Microsoft founder Bill Gates made a similar call in 2015.[75]

The energy sector ought to be notorious for the low R&D intensities (R&D budgets as a percentage of sales revenues) of its key players. The Government should therefore lead the effort for free and open inquiry into new ways of generating, storing and transmitting energy.

The majority of energy research is currently driven by the narrow aim of reducing greenhouse gases. In this cause, university departments compete for research funding on projects that often produce advocacy data, rather than groundbreaking research. The quality, meaning or value of the research is sometimes secondary to the process of winning

the grant to fund it. Enforcing tight conditions on research grants has narrowed the vision of researchers and limited creativity, at just the moment that radical thinking and unbounded intellectual exploration is needed.

The government should develop a coherent research strategy that supports much more adventurous academic research into energy. That research should range from theoretical enquiries and laboratory experiments through to trials of new technology. It should also embrace the continuous professional development of mid-career scientists and technologists in energy R&D.

The Government should throw its weight behind this kind of R&D programme in the energy industry, using measures that include:

- A new research institution for battery technology (Green Paper, p16);
- Public-private partnerships to incentivise private investment in high-risk ventures (this is the approach taken, for example, when the state works with pharmaceutical companies to develop vaccines against tropical diseases);
- Procurement and market mechanisms to encourage new technologies that reduce the cost of energy and offer economies of scale
- Prizes for reaching key technology thresholds;
- Greater, better funded collaboration in international research programmes (for example, in nuclear fusion).

3 Create a licensing model to incentivise shale gas and oil extraction

It is estimated that the UK has 700 billion cubic metres of shale gas, one of the richest deposits in the world. There is an estimated £70 billion worth of shale gas in South Wales alone.[76]

The Brookings Institution estimates that the US shale gas revolution has improved the position of American consumers by $74 billion a year. Brookings estimates that household gas bills alone have dropped by a total $13 billion per year, from 2007 to 2013 thanks to the 'fracking revolution'.[77] In Pennsylvania, the state government has generated $1 billion of revenue through the exploitation of shale. By contrast with wind and solar power, shale gas and oil require no subsidy. Exploiting shale in the UK would reduce the cost of electricity and create tax revenues for local and national government.

The techniques of horizontal drilling and hydraulic fracturing are well established, and are indeed bound up with ever more sophisticated IT.[78] The extensive, safe experience gained in the US can be used to organise extraction in the UK, which has one of the toughest regulatory regimes around. As North Sea oil is wound down, skills could be transferred to the shale sector. It is worth noting that the innovative licensing regime established in the 1970s led to massive innovation and the North Sea oil boom. A similar approach, with adaptation to on-shore extraction, could be adopted for shale gas exploitation.

Shale's potential is well understood, but the Government has been cautious and timid. It should put the positive case for exploiting shale as part of the wider aim of reducing energy prices. Opponents have concentrated their efforts on getting local authorities to reject planning applications. The Government could counter by incentivising local authorities to grant licenses for exploration and drilling. It has proposed giving direct compensation to householders directly affected by gas drilling operations; it should now go further and divert a percentage of tax revenue directly to each local authority granting a license. In this way, communities will benefit. Wales, Lancashire and Yorkshire, where shale gas deposits are concentrated, are areas with a history of industry and mining. These bodies should also argue for shale extraction in their areas. With a clear national aim of reducing energy prices or local benefits, they could resist the alarmism of environmental lobbyists.

Conclusion

While the majority of climate scientists agree that man-made climate change is a problem, the wider population remains unconvinced and sceptical.[79] Given the costs imposed by the current bias towards renewables, it is too easy to blame the Big Six energy providers for high prices. Singling them out hides the truth from the wider population. The public is currently unaware of the real costs of the decarbonisation project, and of its negligible effect on CO_2 emissions. The Government now has an opening to outline the real costs and benefits of decarbonisation as the point of departure for new thinking.

Brexit enforces difficult choices. But it also provides the opportunity to radically rethink policy in key areas and win a public mandate for a fresh approach. The Government could win active public support for reducing energy costs. 'Halve energy costs in seven years' could become a policy aim which would win the adherence of millions – from hard-pressed working families to the boardroom.

A policy based on the principles of cheap, reliable energy could reinvigorate the energy sector and spur innovation. Cheap energy could make Britain more attractive inward investors. R&D could even assist the export of British energy. What's more, a drive to make the most of shale could bring new hope to communities currently denigrated as 'post-industrial'.

Cheap, reliable energy isn't just a necessity. It could form a rallying cry, and, if realised, a source of national optimism.

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