Productivity and the Role of Government

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Contents

Executive summary

In its Pre-Budget Report, the UK government focused on policies to increase productivity. It pointed to Britain's 'productivity gap' of 40 per cent with the US and 20 per cent with France and Germany. This gap was measured using output per worker. But output per worker can vary for a number of reasons, not all to do with differences in productivity levels. For example, if workers work longer hours, or if there are a larger number of unemployed people, in one country, then output per worker will be higher, but this does not reflect a higher level of productivity.

This Commentary considers what different measures can tell us about the extent to which Britain faces a productivity gap. Alternative measures tell quite a different story. If we take into account differences in hours worked, our productivity gap with the US falls to 20 per cent. Allowing for differences in the amount of other inputs used, such as the use of plant and machinery, the gap falls to around 12 per cent. Accounting for differences in the age and quality of this machinery, the gap narrows even more. When we look at trends over time, we see that productivity levels have become much more similar in the four countries than they were several decades ago.

The Pre-Budget Report also highlights the low levels of investment in research and development (R&D) and physical investment in Britain compared with other industrialised countries. This is a worrying feature of our economic performance. However, before implementing policies aimed at increasing investment levels, it is important to understand why investment levels are low. They are, in part, due to low levels of government investment.

In the Pre-Budget Report, the government announced its intention to consult on several policy options aimed at increasing productivity and investment levels. The main proposals were concerned with

- increasing fiscal incentives for R&D, particularly for small firms;
- making permanent increased capital allowances for small businesses;
- changes to the tax treatment of venture capital and possible tax incentives for corporate venturing;
- possible changes to the structure of tax-advantaged employee share-ownership schemes.

What impact do we think these new policies might have, and would they be effective at increasing investment levels? Several of them may have merits in their own right, and improving the effectiveness of existing fiscal incentives is always welcome. However, they are unlikely to lead to large-scale increases in investment or productivity levels in the near future. They are mainly aimed at small firms, which do not account for a large share of investment. If we do not face a large productivity gap with the US, but rather have lower levels of investment, then policies to correct these shortfalls could take a generation or longer to have an impact.

1. Introduction

The UK government has focused on productivity as a key policy issue in the run-up to the 1999 Budget. Productivity growth is one of the main driving forces behind long-run economic growth and wealth creation and, as such, achieving long-term productivity growth is clearly an important objective of government. Many existing policies are aimed at doing just this. In its Pre-Budget Report,[1] the government puts forward proposals for several additional measures. But in order to design and implement effective policy, it is important to understand whether Britain has a productivity 'problem' and what form this problem might take. We need to be clear what we are trying to achieve — in what ways are existing mechanisms failing to work efficiently and how effective will new policies be in overcoming these failures?

The Pre-Budget Report suggests that Britain is 40 per cent less productive than the US and 20 per cent less productive than Germany and France. But does a difference in output per worker — the measurement used in the Pre-Budget Report — truly measure the 'productivity gap'? Is output per worker lower in Britain because we are currently operating at less than full efficiency or is it because Britain is using lower levels (or a different mix) of inputs? Alternative estimates[2] give a very different picture from that suggested by the Pre-Budget Report. They suggest that differences in the levels of output in G7 countries could be almost entirely explained by differences in the levels of inputs. This would imply that there is no gap in productivity levels; rather, differences in output per worker largely reflect differences in past investment patterns. So, even when there is no productivity gap, we can still observe differences in labour productivity, but these will be determined by differences in the usage of human and physical capital across countries.

Is this a pedantic economic point or does it really matter which view is correct? If we are currently operating at less than full efficiency, then we can potentially make gains in productivity levels, and output per worker, relatively quickly and at a small cost. On the other hand, if lower output per worker simply reflects lower levels of input, then higher output per worker will only come about through investment — forgoing consumption now for future gains. Investment can encompass both investments in physical capital and investments in human capital through education and training.

This Commentary considers what different measures can tell us about the extent to which Britain faces a productivity gap and why productivity levels might differ across countries. What factors affect productivity growth rates?[3] We then consider what role there is for government intervention and what form any new policies might take. We focus our policy discussion of capital investment on physical capital.

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[1]HM Treasury, 1998.

[2]For example, Dougherty and Jorgenson (1997), a study by two leading US economists in the October 1997 issue of the *National Institute Economic Review*.

[3]The government, in a series of Treasury/DTI seminars in 1998, highlighted areas such as skills, innovation and technology, management practice and entrepreneurship.

2. What is productivity?

'Productivity isn't everything, but in the long run it is almost everything.'

Krugman, 1995

Productivity is a measure of the amount of output we get for a given level of inputs — it is generally measured as the ratio of outputs to inputs. It can tell us about how efficiently the economy is running. It is not a measure of profitability — very profitable firms can have low productivity and vice versa. Nor is it a measure of overall welfare in society — raising productivity levels will not always increase welfare.

Everything else being constant (i.e. for a given level of inputs), a higher productivity level enhances total welfare because it means we produce more output using the same amount of inputs. If one firm can produce a car using two workers and five pounds of steel, but another firm needs two workers and six pounds of steel to produce exactly the same car, then the second firm is clearly less productive — there is a gap in the productivity levels of the two firms. The second firm would be more productive if it could use less steel. Unfortunately, differences in productivity are not usually that easy to measure — firms do not usually produce exactly the same good, nor do they generally use exactly the same type of inputs.

Productivity growth does not necessarily increase the welfare of everyone. For example, an increase in productivity may be accompanied by a shift in the level of use of some inputs, relative to others. The impact on welfare will depend upon how the shift affects the relative incomes of individuals and how we value the incomes of these different individuals. If a new technology means that we use more skilled labour and less unskilled labour, this may have consequences for employment levels and for the relative wages of skilled and unskilled workers. We may be concerned about the distributional consequences of this change. Even if we could redistribute incomes between people, we might think that participating in the labour market was itself an important component of welfare. Recent empirical work has suggested that the increase in wage inequality in the US and the UK over the 1980s can be partly explained by the introduction of new technologies that favoured skilled workers over unskilled workers over the same period.[4]

Productivity measures can tell us about how well the economy is functioning in both a *static* and a *dynamic* sense — that is, they can be used to consider both static and dynamic efficiency. Figure 2.1 illustrates static efficiency. The analysis here assumes that the best technology that is available is fixed. In this static world, our concern is to make sure that as many firms as possible are operating at the technological frontier — that is, that they are choosing the optimal mix of resources (are *allocatively* efficient) and are putting them to use in the best way (are *technically* efficient).

In recent years, economists and policymakers have been more concerned with dynamic efficiency, which accounts for the fact that technology does not remain unchanged over

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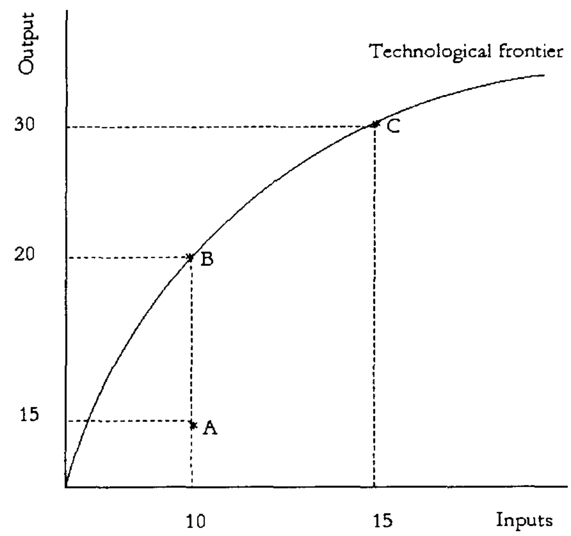
[4]See, for example, Machin and Van Reenen (1998). Note that inequality may also have an impact upon growth and productivity; see Aghion and Howitt (1998) for a discussion of the literature.

Figure 2.1. Static efficiency



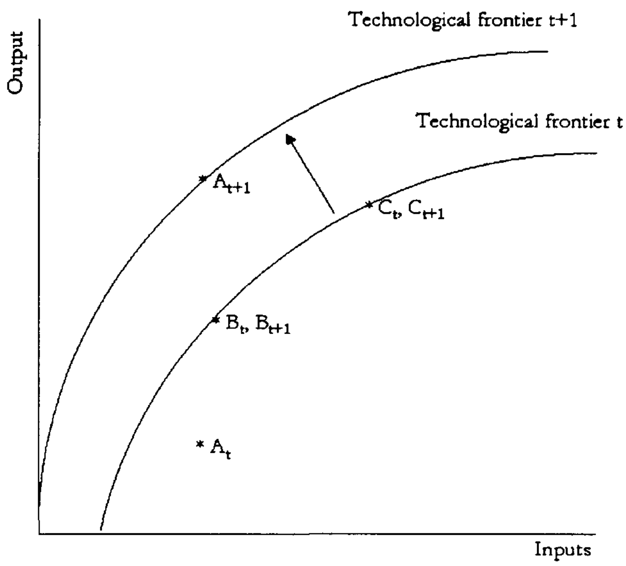
The horizontal axis indicates some level of inputs (for example, the number of person-hours worked, or an index that reflects hours worked and capital, energy and materials used). The vertical axis represents the amount of output produced (for example, the number of cars). Firm A is inefficient relative to Firm B. For 10 units of inputs, Firm A produces 15 cars, but Firm B can produce 20. Firm C both uses more inputs (15 units) and produces more outputs (30 cars), and it is as efficient as Firm B. They both lie on the technological frontier which defines the maximum number of cars that can be obtained at each level of inputs, given current technology.

time. Figure 2.2 illustrates what we mean by dynamic efficiency. Firms play a key role in developing and introducing new technologies. A stated aim of government policy is to encourage this innovative activity and to ensure that the economy can adapt efficiently to new technologies and changing markets.

While some policies can promote both static and dynamic efficiency, we often face a trade-off between the two. Some policies may be good at ensuring that the maximum number of firms are operating at the current technological frontier, but at the same time provide a disincentive for firms to innovate and push the frontier forward. These policies increase firms' incentives to catch up, i.e. to improve their performance by adopting technology that has been developed elsewhere. Other policies may enhance incentives for each individual firm to innovate, but in doing so make it difficult for those that do not operate at the frontier.[5] Government policy may also be aimed at directly pushing forward the technological frontier. There are important differences in terms of the cost and time-scale of these two types of policies. Developing new technologies involves investment; this means that we have to consume less today in order to increase income in the future. The gains may be slow to realise. On the other hand, adopting current best practices can lead to rapid gains in productivity and potentially be less costly.

[5]An example of a policy that does the latter is the patent system.

Figure 2.2. Dynamic efficiency



Consider the behaviour of the same three firms over two time periods, t and t+1. In period t, the firms are as in Figure 2.1. Suppose that Firm A is operating below the technological frontier because it does not have access to the technology that Firm B is using (Firm B could own a patent on that technology). Firm A may have incentives to invest in its own technology. Say it does this and the technology turns out to be better than Firm B's (Firm A may have been able to build on its knowledge of Firm B's technology). In period t+1, Firm A adopts this technology and moves the technological frontier out so that it is now possible to produce more output for the same level of input. A dynamically efficient economy is one that provides the right incentives for firms to innovate and push forward the technological frontier.

As shown in Figure 2.2, a firm can increase its output either by moving along the technological frontier or by moving from one frontier to another. To move to the right along a technological frontier, the firm has to increase the amount of inputs it uses — for example, by investing in more capital or labour. This does not represent productivity growth but simply growth in inputs followed by a corresponding growth in output.

Productivity growth is when firms move from one technological frontier to another. To do this, a firm can invest in research and development (R&D), innovate and thus push the technological frontier forward. Alternatively, it can adopt technology used by other firms and thus move from a lower to a higher technological frontier. The latter strategy suggests that the benefits to the economy as a whole are greater than the returns to the innovating firm. The endogenous growth literature[6] has emphasised the role of such 'spillovers' in driving long-run growth. Growth theory has suggested that it may not be possible to sustain long-run growth by continuously increasing inputs — productivity growth has been emphasised as playing a key role in long-run growth.

In the next section, we discuss what different measures can tell us about productivity levels and growth rates.

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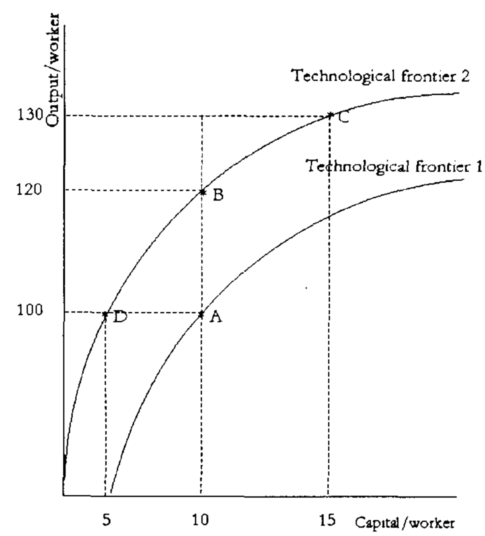
[6]See, *inter alia*, Romer (1990) and Aghion and Howitt (1998).

3. How are productivity levels and growth rates measured?

There are two commonly used measures of productivity — labour productivity, which considers the level of output relative to only labour input, and total factor productivity (TFP),[7] which considers the level of output relative to all inputs (for example, factors of production such as capital, labour and intermediate goods). In its Pre-Budget Report, the government uses output per worker — a measure of labour productivity — to compare productivity levels in the UK and its main industrial partners. This measure of labour productivity can give a misleading picture of productivity levels for a number of reasons.[8] First, it does not account for differences in hours worked. Output per worker will be higher in countries where people work longer hours, although productivity may not be any different. Countries with higher unemployment levels may have higher output per worker because the 'low-quality' workers are unemployed. More importantly, though, even if we did account for hours worked, this measure still combines two different effects: it could vary between countries both because the countries are on different technological frontiers (a productivity gap exists between them) and because they are using a different mix of inputs (for example, they have a different capital–labour ratio) and are therefore on different points on the same technological frontier. This point is illustrated in Figure 3.1.

Suppose that we measure output per worker correctly, and that the UK is at point A and uses 10 units of capital per worker to produce 100 units of output, while the US is at point C and uses 15 units of capital per worker to produce 130 units of output. We would observe a 30 per cent difference in output per worker. This difference reflects two

Figure 3.1. What does output per worker measure?



[7]Sometimes also called multi-factor productivity (MFP).

[8]There are numerous other problems, such as controlling for differences in cyclical trends, that could also be of concern.

factors — that the US is operating on a higher technological frontier and that it is using a more capital-intensive mix of capital and labour. To measure the productivity gap — the distance between technological frontiers 1 and 2 — we want to compare the two countries while holding the capital–labour ratio constant. This means that we want to compare point A with point B. At point B, we see that if the US had used the same amounts of capital and labour as the UK, then it would have only produced 120 units of output. Thus the productivity gap would be 20 per cent. The measure of inputs accounts for capital and labour inputs; therefore the measured gap in output per worker between points A and B, where the capital–labour ratio is the same for both countries, coincides with the gap in total factor productivity.

An additional problem arises in making sure that we have measured the input of capital and labour correctly; in particular, we need to make sure that we have controlled for differences in their quality. Suppose we had measured capital inputs incorrectly for the UK by overestimating the amount of capital used because we had not taken into account the fact that capital was older in the UK and thus of a 'lower quality'. This would mean that we had mistakenly placed the UK at point A. Suppose that, when accounting for quality differences, the UK would actually be at point D, using only five units of capital per worker to produce 100 units of output. Once we control for these differences in quality, we would still see a difference of 30 per cent in output per worker, but no productivity gap.

It is important that we understand whether the observed difference in output per worker arises partly due to a productivity gap because we are on a different technological frontier (point A versus point B), or whether it reflects the fact that we are operating at different points on the same frontier (point D versus point C). In order to move from point A to point B, we have to adopt the leading-edge technology. This could involve new investment in physical or human capital, or it could be a process that is fairly quick and costless. To move along the technological frontier, from point D to point C, we have to invest (so we have to consume less now) and the likely time-scale will be longer.

In practice, it is difficult to obtain accurate estimates of TFP levels or growth rates. We often do not have good measures of either the amounts or quality of inputs used or the amount or quality of output produced. It can also be difficult to know how to represent the technology used to combine the inputs to produce the output. These problems lead to measurement error and mean that measures of TFP often capture many factors other than genuine shifts in the technological frontier.[9]

In the next section, we discuss the levels of both output per worker and total factor productivity in the UK, France, Germany and the US, and consider what they tell us about whether or not the UK faces a productivity gap.

[9]See Griliches (1998).

4. UK productivity

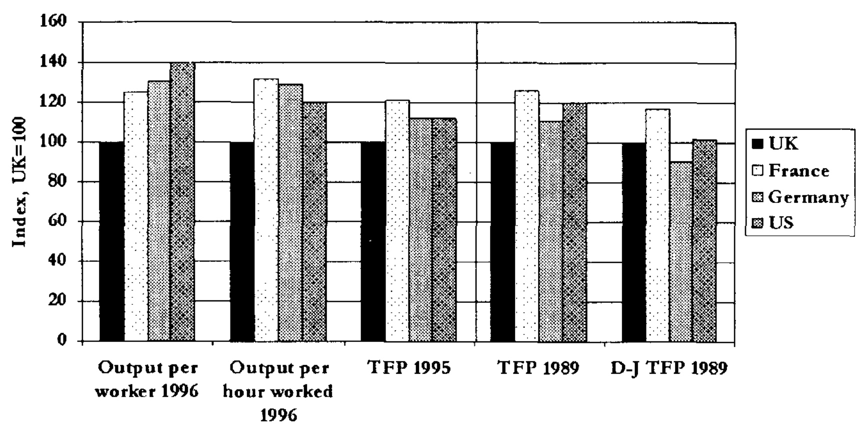
Is there a productivity gap between the UK and her main industrial partners, and, if so, how big is it? Has this gap narrowed or become wider over the past few decades? Are differences in productivity levels something we should worry about? These are difficult questions to answer and there is some conflicting evidence, but before considering the role for government intervention in improving productivity, it is important to understand where we currently stand. In this section, we discuss the findings of several recent empirical studies.[10]

We first consider the current level of productivity in the UK relative to the US, France and Germany. We then look at trends in productivity growth over time, which will inform us about how much UK productivity levels are diverging from or converging to both levels in these other countries and the technological frontier.

4.1 Current UK productivity levels

In its Pre-Budget Report, the government states that 'the UK has a productivity gap with the United States of around 40 per cent and around 20 per cent with France and Germany'. This figure is based on comparisons of output per worker. As discussed above, there are several problems with using this statistic to compare productivity levels. Measuring aggregate output per person does not take account of differences in working hours or numbers employed, differences in capital inputs and differences in the quality of inputs. In the Pre-Budget Report, the government acknowledges these problems but states that 'much the same basic picture of the relative weakness of UK performance emerges, whichever data source or approach is used'.

Figure 4.1. Alternative productivity measures (relative to the UK)



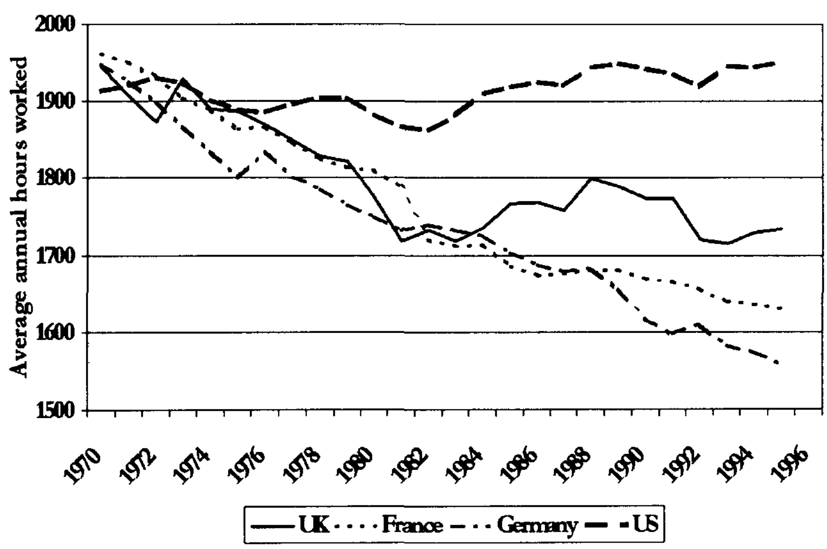
Sources: HM Treasury, 1998; O'Mahony, 1998; Dougherty and Jorgenson, 1997.

[10]The main studies considered are the Pre-Budget Report (HM Treasury, 1998), National Institute of Economic and Social Research (1997), O'Mahony (1998) and a recent book published by the Bank of England, Proudman and Redding (1998).

Figure 4.1 shows that using alternative measures of productivity can have a significant effect on the size of the observed productivity gap. Moving from left to right, the measured productivity gap decreases as we control for differences in hours worked, in capital inputs and in the quality of inputs. Each set of four bars represents a different measure. They are all measured relative to the UK, i.e. the UK is always 100. A bar lower than 100 means that the relevant productivity measure was lower in that country than in the UK.

The set of bars on the left of the graph (output per worker 1996) is from the Pre-Budget Report. This measure shows the US 40 per cent above the UK, and France and Germany about 20 per cent higher. The second set of bars from the left (output per hour worked 1996) accounts for the fact that workers in the US work longer hours than workers in the UK, Germany and France, as shown in Figure 4.2. We see that adjusting for this difference reduces the size of the gap: the US is now around 20 per cent higher than the UK. The third set of bars from the left (TFP 1995) is a measure of total factor productivity. This takes account of differences in the amount of capital used and further reduces the estimated gap. However, this measure of TFP still does not control for differences in the quality of inputs. The fourth set of bars from the left shows this same measure of TFP, not controlling for differences in quality, for 1989. This is so that we can compare it with the final set of bars (D-J TFP 1989), which is a measure of TFP that controls for quality (but which is unfortunately not available for more recent years). This quality-adjusted TFP measure shows a very different picture: the US and UK seem to have about the same level of productivity. Measuring inputs accurately and controlling for differences in work hours, skill levels and physical capital investment in different industries leads the authors to conclude that 'differences between the levels of output per capita in the G7 are now largely explained by differences in the levels of the inputs'.[11]

Figure 4.2. Average annual hours worked



Source: International Sectoral Database, OECD, 1997.

[11]Dougherty and Jorgenson, 1997. Oulton (1997) reaches a similar conclusion using different data and a different methodology.

What do all these different numbers tell us? Referring back to Figure 3.1, the observed 20 per cent difference in output per worker-hour combined with next to no difference in total factor productivity levels (after adjusting for differences in quality) seems to suggest that the UK is at a position like point D, while the US lies somewhere between points B and C.

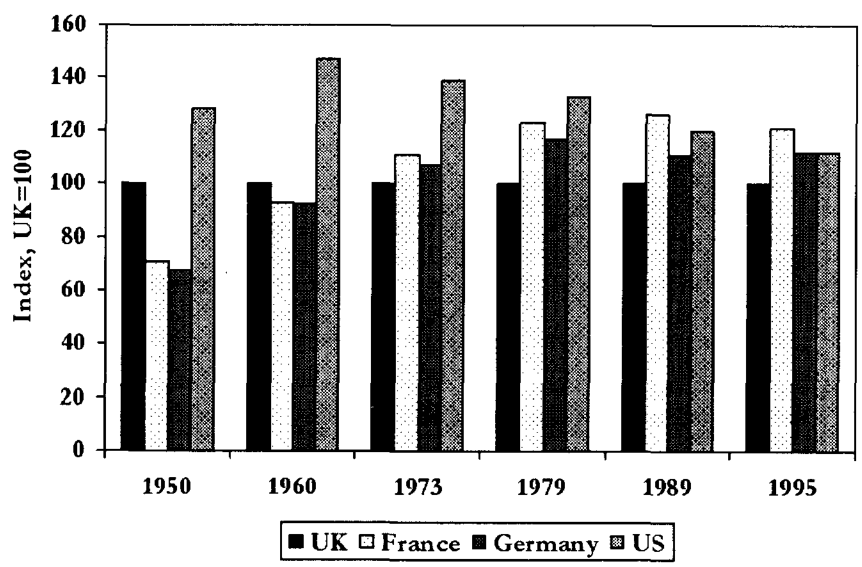
Before turning, in Section 5, to a discussion of why we might see differences in output per worker or in productivity across countries, we first describe some longer-run trends in levels and growth rates of total factor productivity.

4.2 Trends in UK productivity

The 1980s saw significant growth in output per worker (labour productivity) and total factor productivity in many sectors of the UK economy.[12] However, the 1980s largely represent a period of catch-up to long-run productivity growth rates after a period of slow growth, and even some decline during the 1970s.

If we look back to the turn of the last century, we see that the UK led the world in TFP levels. However, obtaining accurate and consistent data over such a long period is difficult. Figure 4.3 shows the relative levels of TFP for selected years since 1950. This is the same measure of TFP shown in the third and fourth set of bars in Figure 4.1, i.e. it is *not* adjusted for differences in the quality of inputs. Figure 4.3 shows the relative level of

Figure 4.3. TFP over time
(relative to the UK)



Source: O'Mahony, 1998.

[12]See Layard and Nickell (1989), Bean and Symons (1989), Davies and Lyons (1991), Nickell, Wadhwani and Wall (1992), Crafts (1993), Oulton and O'Mahony (1994), Bean and Crafts (1995), Mayes (1996), Cameron, Proudman and Redding (1998a) and Oulton (1998). It should be noted that the 1980s also saw a significant rise in inequality: see Goodman, Johnson and Webb (1997).

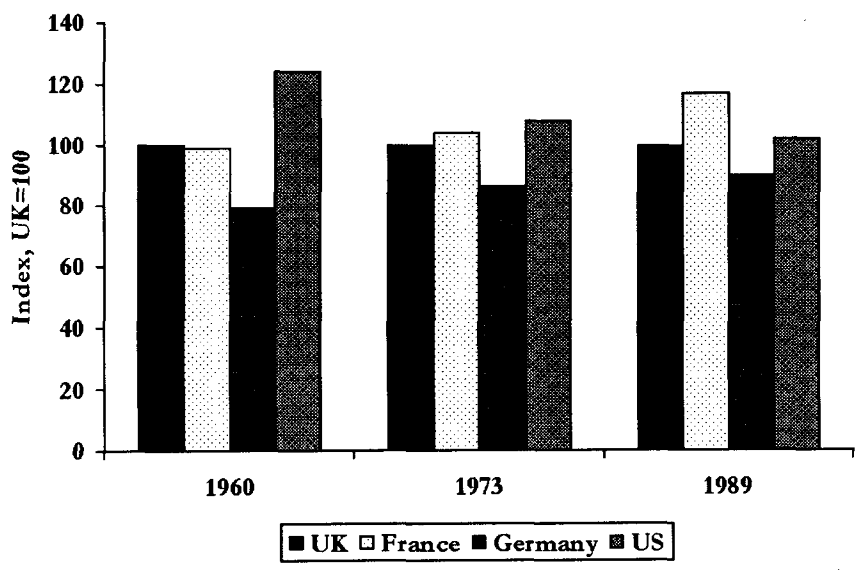
TFP in the market sector measured relative to UK TFP in each year — a value of 100 means that the level of TFP is the same as in the UK for that particular year, a value below 100 means the country had lower TFP than the UK and a value above 100 means it had higher TFP.

Comparing UK TFP with US TFP shows that, while the gap between the two grew between 1950 and 1960, it has narrowed significantly since the 1960s. From 1960 on, productivity in the US grew at a slower pace than that in the UK, so that the gap in TFP fell from around 50 per cent in 1960 to around 12 per cent in 1995. Over the same period, the levels of TFP in France and Germany overtook that in the UK. France and Germany experienced faster growth than the UK until 1979, when it levelled off. However, between 1979 and 1995, the UK grew faster than both France and Germany, narrowing the gap in TFP.

What sort of picture emerges if we look at the quality-adjusted measure of TFP? Figure 4.4 shows relative TFP for three years using the same measure as was reported in the final set of bars in Figure 4.1 (D-J TFP). This measure shows that the gap with the US has largely closed, falling from around 20 per cent in 1960 to zero in 1989. France has experienced more rapid growth than the UK, with the gap rising from zero in 1960 to just under 20 per cent in 1989. Germany has grown slightly faster than the UK, but by 1989 still had a lower level of TFP.

So far, we have only considered economy-wide measures of TFP. Looking at aggregate data masks variations in growth rates between different industries. Growth in total factor productivity in the UK was positive over the 1970s in some industries (for example, computing, pharmaceuticals and electronics), even though TFP growth on average for total manufacturing was negative. In the 1980s, industries such as food and drink, minerals and machinery experienced relatively slow growth. Aggregate TFP could grow

Figure 4.4. Relative TFP levels over time: quality-adjusted



Source: Dougherty and Jorgenson, 1997.

either because the level of TFP increases within each industry or because industries that are unproductive become a smaller part of total production. The majority of TFP growth in the UK was of the former type — within-industry growth — rather than the latter — between-industry growth or a reallocation of resources between industries.[13]

Similarly, when making international comparisons, the picture at the industry level can differ from what we observe at the aggregate level. Some evidence suggests that the UK leads the way in some industries within both the manufacturing and the service sectors — for example, chemicals and insurance.[14]

Examining international trends raises the question of whether TFP levels and growth rates are converging across countries. Empirical evidence suggests that they are converging, and that the main reason for this over the period 1970–87 was an increase in productivity in non-manufacturing sectors, in particular in the services sector.[15] A smaller but significant proportion of aggregate convergence is attributable to changes in the composition of aggregate TFP — that is, shifts in production between sectors.

What analysis at the industry level tells us is that different industries experienced very different growth patterns. We now turn to consider what factors might explain these differences. It is useful to understand why some industries were successful in increasing productivity while others were not. Was it because they innovated and pushed forward the technological frontier, or did other changes mean that more firms became able to adopt current best practices?

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[13]Cameron, Proudman and Redding (1998a) find this, despite significant changes in the composition of what was a shrinking manufacturing sector during the period 1970–89.

[14]See O'Mahony, Oulton and Vass (1996) and Harrigan (1997).

[15]Bernard and Jones, 1996.

5. The determinants of productivity

Economists since the profession began have been interested in explaining why some firms, industries or countries appear to have higher productivity, or to have experienced more rapid growth in productivity, than others.[16] The large body of work that exists offers many explanations. For example, looking at the 1980s, many alternative theoretical and empirical explanations have been offered for the high growth rates we observed. This period of productivity growth, which has been termed the 'Thatcher miracle', coincided with many changes to the UK economy — the weakening of trade unions, rapid shake-outs of labour and of firms in the recession of the early 1980s, deregulation and privatisation, computerisation, increases in the quality of the labour force and an increase in the inward flow of foreign direct investment.

The main sources of productivity growth we focus on here are technological and organisational innovation, increases in human capital and the effectiveness with which new ideas are diffused through the economy. We briefly discuss the ways in which these factors might affect productivity and how markets might be failing to provide the right economic incentives. In Section 6, we consider how effective several of the new policy measures considered in the Pre-Budget Report might be at overcoming these failures.

The areas considered are broadly those highlighted in the government's Pre-Budget Report: enterprise and innovation, investment, competition and regulation, and skills. We also separately consider the role of small firms in economic growth, as the main policies being considered by the government are targeted at small firms.

5.1 R&D and technological innovation

The discovery of new technologies and new ways of organising production move the technological frontier forward. Improvement in the quality of existing products and the introduction of new products also increase productivity. These activities create wealth, since they allow us either to increase output or to produce the same level of output using fewer inputs. As our wealth increases, we can choose to consume more goods and services or spend less time working and more time on leisure activities.[17]

Economists as far back as Smith, Ricardo and Marshall emphasised the important role of technology in promoting growth. Schumpeter described a process of creative destruction where entrepreneurs seek to gain a competitive advantage over their rivals by innovating, thus pushing the technological frontier forward.[18] More recently, the endogenous growth literature[19] has emphasised the important role played by technology. Solow popularised

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[16]Adam Smith, for example, discussed productivity in pin factories. For more recent discussion see, *inter alia*, the work of Griliches, Jorgenson and, in the UK, Crafts, Nickell and researchers at the National Institute of Economic and Social Research.

[17]As noted earlier, how the increase in wealth is distributed between different members of society is an important issue, but one that we assume here is dealt with using other policy tools.

[18]Schumpeter, 1942.

[19]See Aghion and Howitt (1998), Grossman and Helpman (1991) and Barro and Sala-i-Martin (1995).

the idea that unexplained growth in TFP could be attributed to technological progress.[20] In the 1950s and early 1960s, economists such as Schmookler and Griliches began formally to link innovation and R&D expenditure with productivity growth,[21] and since then much empirical work has suggested that R&D and innovative activities play a large role in productivity growth.[22]

The incentives for individuals or firms to innovate are shaped by many factors. Perhaps the most important is the profits (economic rents) that are generated by their innovative activity. The majority of innovative activity (whether measured by R&D expenditure, patents or innovations) is carried out by firms that are large both in absolute size and with respect to the markets in which they operate. However, at the industry level, it appears that competitive industries produce more innovations.[23] Competition comes not only from the domestic market, but also by opening up domestic and foreign markets through international trade and investment. This can increase firms' incentives to innovate both by increasing the size of the market and by increasing the level of competition from other firms.

The process of innovating involves creating knowledge, and knowledge is a public good. This means that creators of knowledge face an *appropriation problem* — once knowledge is in the public domain, it is virtually costless for others to acquire and use it. In addition, the fact that one person uses it does not prevent others from also applying it. These characteristics mean that inventors may not be able to recoup sufficient rewards to their innovative efforts.[24] It is generally thought that the appropriation problem would lead to the underprovision of R&D in an entirely free market.[25]

One form of government intervention that offers a partial solution to the appropriation problem is the patent system. Granting exclusive rights to innovators gives them temporary market power, and therefore provides them with additional incentives to innovate. However, the design of the patent system is itself an issue for debate. Ascertaining the optimal length of time and width of coverage of a patent involves trade-offs between dynamic efficiency and static efficiency. Patent life should be sufficiently long to provide incentives for innovation, but as the technology will not be employed competitively during that period, this implies allocative inefficiency. Determining the optimal width of a patent (i.e. the extent of what it covers) also trades off the social benefits from others inventing around it and the ability of the owner to earn rents. Static efficiency will be improved if the knowledge is used more widely, but this may be at the

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[20] Solow, 1956, 1957 and 1960.

[21] See Schmookler (1952), Griliches (1963 and 1964), Griliches and Jorgenson (1966) and Jorgenson and Griliches (1967).

[22] See Griliches (1992 and 1995) for surveys of the vast literature relating R&D to productivity growth.

[23] Empirical evidence associating competition and innovation includes Geroski (1994) and Nickell (1996), who finds evidence that productivity is positively related to the number of competitors a firm faces.

[24] This may be compounded if there is an asymmetric information problem such that potential acquirers of knowledge cannot accurately assess its value and so do not offer sufficient reward to the inventor.

[25] While there are theoretical reasons why firms might have a strategic incentive to over-invest in R&D, the empirical evidence is largely in favour of the under-investment hypothesis. See Griliches (1992) for a survey.

expense of incentives for innovation and hence at the expense of dynamic efficiency. This implies that the design of the patent system will affect the rate at which technology is diffused throughout the wider economy.[26]

In addition, the patent system may not be an optimal instrument for all industries. Obtaining a patent may mean that the firm discloses some of its knowledge to rival firms. Some firms may be better able to appropriate the returns to their R&D through secrecy.

Another form of policy intervention is for the government to directly fund or conduct some research. This direct intervention can be rationalised as a way to increase the aggregate level of R&D. It also might be the case that some types of research would not be undertaken by the private sector. The full social returns to some types of basic research may be more likely to be realised if it is publicly funded and the results are widely disseminated. However, even where government funds research, it often does not choose the direction of the research (for example, in universities and research institutes).

Another reason why firms might under-invest in R&D is that they face difficulties in obtaining finance for innovative activity.[27] This market failure may exist because it is difficult for the firm to convey the appropriate information to potential investors (the problem of asymmetric information). By definition, innovation involves uncertainty, but potential financiers may be less well informed than entrepreneurs about the quality of an innovative project and be unable to assess progress once the project is underway. Those in need of finance may also be reluctant to reveal their ideas.

5.2 Organisational innovation

It is not only technological innovation that increases productivity but also organisational innovation. Many factors potentially influence managerial and employee performance. Incentives to catch up with management best practice and engage in organisational innovation may be provided from a variety of sources, such as company financial structure and the structure of corporate governance, the intensity of product market competition, the managerial labour market, and performance-related pay or employee share-ownership.

Corporate governance structure may affect managers' performance. Two stylised systems are often distinguished, which are roughly based on the German/Japanese and US/UK models. In the first, ownership is associated with long-term shareholders who are likely to hold significant stakes in the firm and have significant influence over management decisions. The second system involves large equity markets and dispersed shareholdings, owned perhaps by individuals or financial institutions who may have limited involvement with the firm. While the first system may involve closer monitoring by the firm's owners, in the second system the threat of take-over may act as an additional discipline on managers' behaviour.[28] It has been argued that the second system induces short-termist

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[26]For discussions of optimal patent systems, see Klemperer (1990).

[27]See Hubbard (1998) for a discussion of financial constraints.

[28]See, *inter alia*, Franks and Mayer (1996).

behaviour on the part of managers, i.e. long-run investment projects may be sacrificed at the expense of short-run profits.[29] Incentives to make high dividend pay-outs can affect investment levels if investment is dependent on cash flow.[30]

The intensity of competition in the product market faced by a firm will affect incentives for organisational as well as technological innovation. The extent to which managers are exposed to management best practice should affect the rate of catch-up and incentives to build upon it. A recent study provides evidence that, in more competitive markets, there is less dispersion of productivity levels — that is, more firms appear to operate on or near the technological frontier.[31]

Theory suggests that linking employees' remuneration to their own or company performance sharpens work incentives. For management, linking pay to firm performance may affect their investment decisions and the adoption of best practice. While there is some evidence to suggest that profit-sharing and employee share-ownership schemes do have an effect on the level of productivity,[32] evidence also exists to show that people substitute the form of their income from salaries to share options in order to defer (or even avoid) tax payments.[33]

5.3 Human capital

Improvements in the quality of the labour force have played a key role in productivity growth. Theoretical models[34] emphasise the importance of human capital accumulation as a source of long-run growth. Evidence for this goes back to the early work of Schultz, who estimated that growth in total human capital could account for around one-fifth of output growth, and Jorgenson and Griliches, who found that improvements in the education of the US work-force could account for, at that time, approximately one-third of TFP growth.[35]

Human capital is acquired in many ways: through formal education, on- and off-the-job training and learning by doing. A broad educational background means that workers are able to do a wider range of jobs and hence be more adaptable to changes in the workplace. Job-specific training can also raise workers' productivity, and some skills may be transferable between jobs and workplaces.

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[29]For a summary of theory and empirical evidence on this issue, see Nickell (1995).

[30]See, *inter alia*, Bond and Meghir (1994).

[31]Oulton, 1996. See also Nickell (1996).

[32]See Weitzman and Kruse (1990), Mitchell, Levin and Lawler (1990) and Jensen and Murphy (1990).

[33]See, *inter alia*, Gordon and MacKie-Mason (1997) and Gordon and Slemrod (1988).

[34]See, for example, Lucas (1988) and Barro and Sala-i-Martin (1995).

[35]Schultz, 1960; Jorgenson and Griliches, 1967.

Human capital is also an essential input into innovative activity. Two-fifths of R&D expenditure goes on skilled labour.[36] Higher education is particularly important for research and innovation. In addition, the movement of workers between firms may be an important way in which new ideas are diffused around the economy.

A market failure may arise in education and training because social returns may exceed private returns to individuals. There may exist positive externalities to education — for example, training may raise not only the productivity of skilled workers but also that of unskilled workers in the same or even other firms. The divergence between social and private returns could lead individuals to under-invest in education and training, from the perspective of society as a whole, if they had to pay the full cost of their education. This suggests a role for government in subsidising education and training.

Firm- or job-specific skills will also improve productivity. Firms may fail to provide enough workplace training if, for example, they are uncertain about whether the employee will stay with the firm. Individuals themselves may want education or training but may not be able to finance it because private lenders are unwilling to lend to them. These factors mean that there is a role for the government in both providing and funding education and training. As in other developed countries, the government already does this in the UK.

Evidence linking skills and productivity comes from international matched-plant studies.[37] These studies find large productivity differentials between the UK and the Continent for the industries examined. Mason and van Ark cite slower investment in new physical capital and lower average levels of human capital as sources of the performance differential between Dutch plants in the engineering sector and their British counterparts.[38] O'Mahony finds human capital to be as important as physical capital in explaining an observed difference in labour productivity per worker-hour between UK and German manufacturing.[39]

5.4 The diffusion of ideas

Productivity at the industry or country level is a function not only of where the technological frontier lies but also of how many firms operate on or near the frontier. Therefore the effectiveness of how new ideas are transmitted from one firm to another, from one set of workers to another or from firms and workers in one country to firms and workers in another country will affect productivity levels. Because of this, economists are interested in how technologies and ideas are diffused throughout the global economy. This is the process by which knowledge 'spills over'.

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[36]For the UK in 1996, 45 per cent of current R&D expenditure (current R&D expenditure makes up 90 per cent of total R&D expenditure) was attributed to salaries and wages. Source: http://www.dti.gov.uk/ost/SETstats98.

[37]Prais, Jarvis and Wagner, 1989; Mason and van Ark, 1996.

[38]Mason and van Ark, 1996.

[39]O'Mahony, 1992.

One important way in which technology is spread around the economy is through new goods and services that embody this new technology, which is why we might think that new investment is important for productivity. Another important way is by workers moving from one company or one industry to another.

Different technologies will vary in the extent to which they can be used. Some technologies will only by useful for a very few firms or industries. Other technologies are characterised by their wide applicability throughout economies and, as such, have been termed 'general-purpose technologies'. A good example of a widely applicable technology is computers and information technology. One key factor affecting how rapidly and effectively new technologies can be adopted is the level of human capital — in order to use new machines and ideas, we often need skilled workers. This means that skilled workers and technological innovation are complementary.[40]

It has long been recognised[41] that one of the reasons we observe the agglomeration, or clustering, of production in particular geographic areas is that this enhances technological spillovers, along with providing access to specialist labour and intermediate inputs. When firms are located near each other, the transfer of knowledge may be quicker and more efficient, enabling less-productive firms to catch up to the technological frontier more quickly. Why is this the case? It may be that it is difficult to *codify* some knowledge, and hence it must be transferred through direct contact. Workers moving between firms and into and out of universities and other research centres may be important for this process. Much emphasis has been given to the existence of such spillovers in discussion of the success of Silicon Valley or other high-tech firms that are clustered around the M4 corridor and academic institutions such as the Cambridge 'Silicon Fen'.

In a domestic context, the diffusion of new ideas and work practices will probably depend on factors such as the mobility of labour between firms, the geographical proximity of firms and the degree of competition in the product market. It may also depend on the organisational structures in place and their ability to adapt to a changing environment.

Empirical and theoretical work in the US[42] suggests that spillovers are initially localised but that geographical proximity becomes less important over time. Increases in the free flow of goods and factors of production between countries can lead to increases in productivity in a number of ways. First, economic activity becomes more efficiently organised. If, for example, German firms are good at producing cars and British firms are good at producing pharmaceuticals, then both countries can gain by specialising in what they are good at and trading with each other.

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[40]See, for example, Redding (1996) and Aghion and Howitt (1998). Models that incorporate this complementarity generate two equilibria — one using high-skilled workers and producing high-quality goods, the other using low-skilled workers and producing low-quality goods.

[41]See Marshall (1920) and, more recently, Dunning (1977 and 1981), Krugman (1991a and 1991b) and Caves (1996).

[42]See, for example, the work of Jaffee, Traijtenberg and Henderson (1996), which measures knowledge spillovers by patent citations.

Second, it is possible that foreign firms that choose to produce in the UK are more productive than domestic firms.[43] If this is true, then more-productive multinational firms will replace less-productive domestic firms and thereby increase the overall level of productivity.

Third, international openness can affect the rate of technology transfer. Foreign firms can bring new technologies which domestic firms and workers can then learn from, thus pushing the UK closer to the technological frontier. It may also be the case that foreign firms induce an increase in productivity at other levels of the supply chain — for example, by demanding higher-quality intermediate inputs. Factors such as skill levels will affect Britain's ability to take advantage of technological spillovers, but foreign firms may also train workers and thus increase productivity.

On similar grounds, outward investment can also play an important role in facilitating knowledge spillovers and the transfer of technology. British firms locating abroad can learn from firms in other countries and bring this knowledge back to the UK. Where they locate will have particular importance if spillovers are geographically concentrated around the location of R&D or production. Evidence of international spillovers at an aggregate level suggests that foreign R&D has a positive effect on domestic productivity, and that this is aided by international trade.[44]

What role does the government have to play in encouraging diffusion? There may be some role in facilitating links between research institutes, academic institutions and business, although if this were a profitable pursuit, we would expect firms to be doing it already.

Where firms initially locate may depend on intervention by government, either through direct subsidies or indirectly through other policies. Investment in new goods is one important way in which technology is diffused. One particular form of investment — foreign direct investment (FDI) — has attracted attention as a potential productivity driver. Offering a subsidy to foreign investors (that is greater than for domestic investors) is only justifiable if we believe that the potential spillovers from foreign investment are greater than those from domestic investment. This sort of subsidy could introduce a costly distortion. If *market forces* mean that firms choose to locate where they are most productive, then, by distorting their decisions, we could actually decrease efficiency. Removing unnecessary barriers to trade and relocation, however, may be important.

International trade in goods and services appears to have played an important role in driving UK productivity growth in the 1980s. Studies using aggregate data from 1962 to 1992 suggest that the stock of R&D capital, which is measured by both UK-industry-funded R&D and payments for imported technology, had a significant effect on

[43]Theoretical models suggest that this is true, though there is little empirical evidence to support this — see Simpson (1994), Oulton (1998) and Griffith (1998). In addition, a significant proportion of foreign direct investment will come from mergers and acquisitions.

[44]See, for example, Coe and Helpman (1995) and Cameron, Proudman and Redding (1998b).

productivity in manufacturing.[45] A Bank of England study[46] suggests that sectors that were classified as 'relatively open' in 1970 had higher rates of productivity growth in the period up to 1992. It finds that the rate at which a sector converges to the productivity level of the US depends on the flow of goods and ideas but not on the flow of capital. Its evidence also suggests that the level of human capital has a positive effect on the rate of technology transfer.

5.5 The role of small companies and start-ups

Most of the policies being considered by the government are targeted at small companies and start-ups. Why might we want to target this group of firms? Do they play a large or important role in promoting technological progress and productivity growth in the UK? Are they harder hit by the market failures discussed above? These are difficult questions to answer.

It is hard to collect accurate data on small firms and they are generally undersampled in government-conducted surveys.[47] One reason for this is that many small firms are actually sole traders or partnerships. From the data we have, we see that small firms,[48] defined here as those with under 100 employees, account for a significant proportion of total economic activity. For example, they accounted for over 32 per cent of employment in 1997. However, they carried out only 9 per cent of total business enterprise R&D expenditure in 1996 (for those in manufacturing, this number is even lower, at 5.3 per cent).[49] It may be that small firms undertake more R&D than these numbers represent because they undertake informal R&D. If we look at the outputs of R&D, they do account for a greater proportion of innovative activity — for example, using a different sample of firms, in 1975 they carried out less than 1 per cent of total R&D, but they accounted for 12.1 per cent of what are termed 'significant innovations' between 1970 and 1979.[50]

While small firms create many new jobs every year, they also shed many jobs.[51] Small firms come and go at a rapid rate. The number of firms in the UK has been fairly constant over the last 10 years at around 3.7 million, but this figure disguises the fact that every year a significant number of firms start up and a significant number go out of business. It is likely that this 'churning' is concentrated disproportionately among small

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45Cameron and Muellbauer, 1996.

46Cameron, Proudman and Redding, 1998a.

47Preliminary results of the Community Innovation Survey suggest that 52 per cent and 72 per cent respectively of small and medium-sized enterprises (SMEs) (less than 250 employees) and large enterprises are 'innovators'. Innovators are described as 'enterprises that introduced any technologically new or improved products, processes or services between 1994 and 1996'. In this survey, 95 per cent of the businesses sampled are SMEs.

48The DTI defines small firms as those with fewer than 50 employees and medium-sized enterprises as those with 50–250 employees. Criteria on turnover and balance sheets are also used. We include firms with at least one but fewer than 100 employees.

49Source: http://www.dti.gov.uk/ost/SETstats98.

50Data from a survey carried out by the Science Policy Research Unit; see Pavitt, Robson and Townsend (1987).

51Hart and Oulton (1996) suggest that small firms do not create more jobs in aggregate than large firms.

firms. DTI statistics report 182,600 new VAT registrations during 1997 and 164,500 deregistrations, which provides a rough guide to the numbers of business start-ups and closures.

It could be that having a larger number of small firms means that the economy is better at evolving — that is, that it creates a more dynamic economy with many firms starting up and the unsuccessful ones going out of business rapidly. Small firms may not themselves be the innovators, but they may be good at filling in gaps in the market more rapidly than larger firms.[52] This is in contrast to an economy dominated by large firms, which may be more bureaucratic and slower to implement change. On the other hand, economies of scale and scope may mean that larger firms that have acquired knowledge and human capital in one production area may be able to apply these more easily in other areas.

Are market failures particularly acute for small and start-up firms? Theoretical models suggest that financing constraints should be more severe for start-up firms — they do not have a previous trading record and therefore may find asymmetric information problems more severe. In addition, high-tech start-ups may be reluctant to reveal their ideas, as a significant proportion of their value is likely to depend on such intangible assets. Whether or not financial constraints are particularly worse for small firms is an empirical issue for which we do not have much evidence.[53]

The majority of small businesses rely on bank loans as their primary source of external finance.[54] However, loans may not be suitable for high-tech start-ups that engage in long-run, high-risk and potentially high-return projects. External sources of finance for high-tech enterprises are venture capital, business angels (i.e. outside individuals who make direct investments in unquoted firms) and equity markets such as the Alternative Investment Market (AIM). Venture capital investments are equity investments in unquoted firms. Investments can be made by institutions via venture capital funds and by individuals through venture capital trusts.

High-tech firms are suitable investments for venture capital funds which rely on high growth to enable them to finance such high-risk investments. The returns to these investments are usually realised by entry to the stock markets in the form of initial public offerings (IPOs). An alternative, and currently more significant, source of finance for start-up firms in the UK is business angels.

It is important to note that not all venture capital goes to fund early-stage high-tech firms. None the less, while the UK channels a significant proportion of funds into later-stage investments and financial restructuring, such as management buyouts, the provision

[52]See, *inter alia*, Geroski (1994).

[53]See also Bank of England (1998) for discussion of this issue and Cressy (1996), who argues that start-ups are not debt-rationed.

[54]See Bank of England (1998). It is worth noting that the government operates a small firms loan guarantee scheme.

of early-stage finance and the provision of finance for high-tech firms are growth areas.[55] In 1997, the UK invested the same proportion of GDP in start-up and expanding companies as the US.[56]

In the next section, we consider what role the government can play in promoting productivity growth.

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[55]The British Venture Capital Association website (http://www.brainstorm.co.uk/BVCA/welcome.html) reports that, in 1997, £670 million was invested in high-tech companies, 15 times the amount invested in 1984. Early-stage investment in 1997 was £159 million, an increase of 21 per cent on the previous year.

[56]Source: British Venture Capital Association cited in *The Economist*, 7–13 November 1998, p. 36.

6. What role is there for government intervention?

In its Pre-Budget Report, the government announced that it was going to consult on several policy options aimed at increasing productivity. The main proposals were concerned with

- increasing fiscal incentives for R&D, particularly for small firms;
- making permanent increased capital allowances for small businesses;
- changes to the tax treatment of venture capital and possible tax incentives for corporate venturing;
- possible changes to the structure of tax-advantaged employee share-ownership schemes.

What impact do we think these new policies might have, and would they be effective at overcoming the market failures discussed above? Several of them may have merits in their own right, and improving the effectiveness of existing fiscal incentives is always welcome. However, we should be clear that the changes being considered in the Pre-Budget Report are unlikely to lead to large-scale increases in productivity levels in the near future. If the analysis presented above is correct, and we do not face a large productivity gap with the US, but rather have lower levels of technological, physical and human capital stocks to work with, then policies to correct these shortfalls could take a generation or longer to have an impact.

It is also important to remember that the government already intervenes in the markets for innovation and education in many ways — for example, through funding research and through operating a state-funded education system. These policies clearly have had, and continue to have, a significant impact on productivity. In addition, the government has already announced several policies — for example, in the Comprehensive Spending Review — that are targeted at increasing investment in R&D and physical and human capital. This additional spending over three years will include £300 million (plus £300 million matched from the Welcome Trust) for new university laboratories and equipment and £400 million for the Research Councils.

But what role is there for *further* government intervention? The key to additional policy measures is whether they strengthen microeconomic incentives for firms and workers to come up with and implement new ideas.

In order for policies to be effective, it is essential that we understand what they are aiming to achieve — for example, are they trying to correct a specific market failure or to redistribute wealth or resources? It is also necessary to ensure that the proposed intervention actually improves matters and does not introduce new distortions.[57]

[57]Measures that are already in place may create their own distortions — for example, due to unforeseen effects or because they were put in place when the economy was structurally different. If such market distortions exist, it might be possible to raise productivity by removing them.

In this section, we discuss several policy options currently under consideration and how effective these policies might be. We also consider whether there are problems with implementation and whether these policies may in themselves introduce new distortions.

6.1 R&D tax credits

The Pre-Budget Report said that the government had considered two possible forms of tax credit:

- 'a research and development corporation tax credit open to all firms based on the incremental increase in R&D spending';
- 'a tax credit based on the volume of R&D spending for small and medium enterprises (SMEs). One method of ensuring that firms not yet in profit, and hence not paying corporation tax, would still be able to gain immediate benefit from this type of incentive would be to make the credit payable directly to these companies'.

The Pre-Budget Report goes on to say that the government believes the case for the latter is stronger. It also stated that it will review the definition of the current scientific research allowance (SRA). The SRA gives firms a 100 per cent deduction for capital expenditure for use in 'scientific research'.

The rationale in the Pre-Budget Report for introducing fiscal incentives is the 'R&D gap' faced by the UK. Table 6.1 provides some international comparisons of R&D expenditure and financing. The concern is that the amount of R&D conducted by business (BERD) as a proportion of GDP (second row), which was reported in the Pre-Budget Report, has fallen in the UK, while it has risen in other countries, and is lower in the UK than in the other countries. However, one of the main reasons for the fall in

Table 6.1. R&D expenditure and funding

	UK	France	Germany	US
1981				
GERD as a percentage of GDP	2.4	2.0	2.4	2.4
BERD as a percentage of GDP	1.5	1.1	1.7	1.7
Percentage of BERD financed by industry[a]	70.0	75.4	83.1	68.4
Percentage of BERD financed by government	30.0	24.6	16.9	31.6
Industry-financed BERD as a percentage of GDP	1.1	0.8	1.4	1.2
1996				
GERD as a percentage of GDP	1.9	2.3	2.3	2.6
BERD as a percentage of GDP	1.3	1.4	1.5	1.9
Percentage of BERD financed by industry[a]	90.5	87.3[b]	91.0	83.6
Percentage of BERD financed by government	9.5	12.7	9.0	16.4
Industry-financed BERD as a percentage of GDP	1.2	1.2	1.4	1.6

[a]Includes domestic and foreign industry, and also 'other' which is a very small category.

[b]Latest figure available for France is for 1995.

Notes:
GERD — gross domestic expenditure on R&D, which covers all R&D carried out on national territory and therefore includes government intramural expenditure on R&D, expenditure by the higher education sector on R&D and BERD.
BERD — business enterprise expenditure on R&D.

Source: Main Science and Technology Indicators, OECD, 1998.

BERD in the UK was the drop in the amount of government funding (largely because of reductions in defence spending). Looking at R&D both financed and conducted by industry (fifth row), we see that it has risen slightly in the UK, and is on a par with France, although below Germany and the US.

What impact does an R&D tax credit have on firms' incentives to invest? It allows firms to offset some or all of their R&D expenditure against their tax bill. This lowers the price of carrying out R&D, which should induce firms to conduct more R&D. Such an intervention is appropriate if we believe that the social benefit to R&D is higher than the private benefit earned by the firm, because of knowledge spillovers. R&D tax credits are also one way of putting more cash in the hands of firms that undertake R&D, thus potentially overcoming any financial constraint these firms might face, albeit maybe not in the most efficient manner.

Many countries, including most of the G7, have R&D tax credits of some form.[58] However, they have proved difficult in practice to design and implement.[59] One important distinguishing feature of different credit systems is whether they subsidise all R&D or only incremental R&D.[60] Incremental systems are more cost-effective[61] but can create perverse incentives when implemented over a number of years. This is because firms will take into account the fact that raising R&D this year will usually mean reducing the value of the credit in the next year. In the US case, some firms ended up facing negative incentives to conduct additional R&D, meaning that the credit had the opposite effect to that intended.[62]

So there are many practical difficulties with implementing a tax credit aimed at incremental R&D, which the government has acknowledged. The government currently favours targeting R&D tax credits at small and medium-sized enterprises. It also points out that, because not all small firms will be in a position to offset any credit against a corporation tax bill, consideration should be given to paying the credit directly to the firms. This is an important design consideration and one that will significantly affect the value of this credit to small firms.

However, the government does not clearly lay out its rationalisation for targeting the incentive only at SMEs. Clearly, this will make it a much cheaper policy to implement, but it will also mean that its overall impact is much less. As discussed above, small firms account for approximately 9 per cent of R&D carried out by business in the UK. If the aim of the policy is to increase the aggregate level of R&D spending in the UK, and thus overcome the current R&D gap Britain faces, then this policy seems unlikely to achieve it. For example, introducing a credit of the form suggested at the rate of 20 per cent

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[58]See Griffith, Sandler and Van Reenen (1995) and Bloom, Chennells, Griffith and Van Reenen (1998).

[59]For example, the American system has had at least 10 changes to its design since its introduction in 1981. See Hall (1993).

[60]Incremental R&D is generally defined as either the year-on-year increase in R&D or an increase above a pre-defined base such as the average of the previous three years.

[61]In a static setting, they can induce the same increase in R&D as subsidising total R&D but at a fraction of the cost.

[62]See Eisner, Albert and Sullivan (1984).

would probably increase the ratio of business-conducted R&D to GDP by less than one-tenth of one per cent.[63]

Amending the definition of the scientific research allowance may represent an attractive way for the government to introduce more generous fiscal treatment of R&D without having to introduce a new type of relief. The key issue in revising the SRA lies in redefining what is considered as capital expenditure for 'scientific research'. Most of R&D spending is on current expenditure (for example, wages and consumables), while capital expenditure (i.e. buying machines and equipment) accounts for only around 10 per cent of total R&D.[64] We do not have figures on what proportion of R&D is classified as 'scientific research', but it is probably a small amount. For example, we do know that current expenditure on 'basic research' accounts for around 8 per cent of BERD. This means that the SRA currently applies to a very small proportion of total R&D expenditure. Two possible reforms the government could consider would be to increase the allowance to greater than 100 per cent or to extend the allowance to a broader range of R&D expenditure.

6.2 Capital allowances

In the UK, as in most countries, we have capital allowances, which allow companies to deduct a certain proportion of their investment from their taxable profits. Firms are currently allowed to offset 25 per cent of expenditure on plant, machinery and land and 4 per cent of expenditure on buildings. In his 1997 Budget, the Chancellor introduced a temporary enhanced first-year capital allowance for small firms of 50 per cent. This meant that, for the financial year 1997–98, small firms could offset an additional 50 per cent of their expenditure in the first year. This was temporarily extended at the reduced rate of 40 per cent in the 1998 Budget. This year's Pre-Budget Report stated that the government will be 'reviewing the case for continuing with enhanced first year capital allowances'. Consideration will be given to making this temporary measure permanent.[65] The government points to a long history of under-investment as a cause of much of the UK productivity problem.

It is fairly widely agreed that the UK has low levels of aggregate investment relative to other industrialised countries. OECD statistics suggest that investment as a percentage of GDP is lower in the UK than in any of the other G7 countries.[66] Table 6.2 shows the proportion in GDP of three different categories of investment for the UK, France, Germany and the US. The first category is total investment, and it appears that the UK

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[63]This estimate is made by assuming that a volume credit is applied at 20 per cent to all firms with fewer than 100 employees. Small firms carried out around 10 per cent of BERD equal to around £900 million in 1996. If we assume an elasticity between 1.0 and 2.0, this would lead to between £150 and£400 million of new R&D. This is around one-twentieth of one per cent of GDP. The figure in the text has been rounded up.

[64]Source: *Economic Trends*, August 1996.

[65]Making this, or any other measure, permanent rather than temporary is welcome. Temporary measures are generally thought to shift the timing of investment without having any significant aggregate effect.

[66]This is also supported by figures in Dougherty and Jorgenson (1997), who suggest that if we look at capital inputs per capita and adjust for differences in the quality of capital, then over the period 1960–89 the UK used less than half the level of the US and around two-thirds of the levels in France and Germany.

Table 6.2. Investment as a percentage of GDP, 1960–95

	UK	France	Germany[a]	US
Gross fixed capital formation	17.9	22.2	22.3	18.3
Gross fixed capital formation excluding residential construction	14.2	15.5	15.7	13.6
Gross fixed capital formation: machinery and equipment	8.3	8.8	8.7	7.5

[a]Figures for Germany refer to West Germany.
Source: OECD Historical Statistics, 1960–95, 1997 edition.

has low investment levels, although not much lower than the US. The second category excludes residential construction, and the four countries look much more similar. The third category looks only at investment in machinery and equipment; here, the UK has a broadly similar investment level to France and Germany, and a higher one than the US.

To the extent that there is under-investment by business in the UK, what can and should the government do? First of all, why do we care about investment in physical capital? One important reason is that technical change may be embodied in capital. Second, if we believe that investors in capital are able to raise sufficient finance, and fully to appropriate the return from their investment, then why are they not already investing enough? One reason might be that the corporate tax system itself will deter some amount of investment that would be undertaken in its absence.[67] Estimates suggest that UK corporation tax adds 1 or 2 per cent to the cost of investing in physical capital (the 'cost of capital').[68] While this will lower the level of investment in the UK relative to a no-tax world, it is not obvious why corporate tax systems in other countries would not have had the same impact.

6.3 Tax treatment of losses

As the Pre-Budget Report points out, because small firms are often not in a tax-paying position, the value of any tax allowance or tax credit for them is much reduced. In the case of the R&D tax credit discussed above, the government seems to be considering some form of refundability, i.e. paying the credit directly to firms when they do not have a current tax liability against which the credit can be set. While the Pre-Budget Report makes no mention of the same considerations for capital allowances, the same concerns would apply. The value of capital allowances is much reduced for firms that do not have any current tax liability.

In general, when a firm makes taxable profits, it makes a tax payment to the government. However, when a firm makes a loss, it does not receive a corresponding payment from the government. Instead, it has to carry the loss forward to set against profits that might be earned in the future. The value of this future offset depends on how long the firm has to wait until it earns profits.

[67]See Dilnot and Giles (1996) and Bond, Devereux and Gammie (1996).

[68]Bond, Denny and Devereux, 1993.

This asymmetric treatment may discriminate against start-ups and firms undertaking long-term or risky investment projects, two categories into which high-tech ventures naturally fall. If firms face a long wait before positive profits are earned, or if there is a significant risk that they may never be earned, there will be a delay before firms can recover the value of tax allowances on investment, which means losing an immediate cash-flow benefit. The delay raises the cost of investment for such firms.

One possible change would be to allow firms to receive an interest mark-up on tax allowances carried forward, which could reduce the discrimination against small or start-up high-tech firms. However, they still face the loss of the potential cash flow. To the extent that cash flow affects investment and R&D, this could have an effect on innovative activity. Possible approaches to this problem might be for the government to provide a rebate or to allow loss-making firms to sell their tax allowances to firms with taxable profits. There are clearly many implementation and cost issues to be thought through here.

6.4 Venture capital

The Pre-Budget Report states that the government will consider measures aimed at helping small quoted companies. It also raises the possibility of encouraging corporate venturing, which is when established companies invest in small and start-up firms.

The possibility that firms face constraints in obtaining start-up finance was suggested as a rationale for government intervention. As we discussed above, the majority of small businesses rely on bank loans as their primary source of external finance, and the UK leads Europe in venture capital provision.

Policies aimed at boosting venture capital finance can be aimed either at the supply or the demand side. Schemes already in place that are aimed at the supply side provide tax incentives for venture capital investments by individuals and investments by business angels. The tax incentives provided are already very generous in comparison with those for PEPs and pension funds, as tax relief is available at all stages of the investment process. Venture capital trusts (VCTs) were introduced in 1995 and invest in unquoted companies. They offer tax relief for investors on subscriptions for new shares, on dividends received and on capital gains tax when the shares are sold. In addition, subscribers for new shares have the ability to defer capital gains from disposals of other assets.

One issue to consider is whether addressing the formal venture capital sector has a significant impact on early-stage financing for small firms. Estimates cited by the OECD suggest that, in both the US and the UK, the informal venture capital sector, which comprises individual investors such as business angels, provides more finance to start-up firms than the formal venture capital sector.[69] Tax incentives are already in place for investments by business angels. The Enterprise Investment Scheme (EIS) provides income tax and capital gains tax relief for outside individuals making new equity investments in unquoted companies that trade in the UK.

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[69]OECD, 1996.

The Pre-Budget Report also discusses the role of corporate venturing. One argument in favour of corporate venturing is that the asymmetric information problem might be less severe for firms that are in the same industry. Established firms may be better able to interpret the business plans of start-ups in the same industry. But would start-ups want to reveal this information to firms that are to some extent competing with them in the same market?

6.5 Share option schemes

The Pre-Budget Report highlights employee share-ownership as an area where there is potential room for improvement. There are two main components to the government's approach in this area:

- 'to promote a long-term partnership between employees as shareholders and the company';
- to consider whether 'special tax-advantaged share incentive schemes might help encourage more high calibre mangers to join and stay with smaller companies'.

These are considered in turn.

As the report acknowledges, there are already two schemes in place to encourage employee share-ownership — profit-sharing schemes and savings-related share options (SAYE) schemes. By the mid-1990s, around one million employees were participating in each scheme. Profit-sharing schemes have an annual income tax relief cost of roughly £100 million, while SAYE schemes receive annual income tax relief of roughly £300 million. One of the government's concerns expressed in the Pre-Budget Report is that employees are not holding shares in these schemes for as long as it would like, and it wants to 'provide stronger incentives for long-term shareholding by all employees'.

But why exactly does it want to do this? Employee share-ownership can sharpen individual work incentives by tying part of employees' incomes to the performance of the firm. However, this necessarily means that the employees bear more risk with regard to their incomes and wealth. Employees who both receive a salary from and hold shares in a single firm are putting all their eggs in one basket. What reasons do we have to think that employees are not currently choosing the appropriate level of trade-off between risk and reward that employee share-ownership implies?

Of particular interest are incentives for entrepreneurs who own shares in their own companies, and the provision of equity-based remuneration to recruit high-quality managers to start-up firms. We have already noted that the stock market provides a dual role for entrepreneurs. As well as a source of finance for investment, the use of stock options as part of a remuneration package can provide high-powered incentives for managers of small quoted firms, in particular those with high growth prospects. It is possible that, by increasing the rewards to risk-taking, more entrepreneurial behaviour would be encouraged, and some high-quality individuals would leave established firms and take up employment in high-tech start-ups.

From 1984 to 1996, the UK had a discretionary, or 'executive', share option scheme. This scheme allowed employers to target specific employees, since there was no requirement for all employees to be offered the scheme. Although fewer employees participated in this scheme than in the 'all employee' schemes — by the mid-1990s, around 200,000 — the annual income tax relief cost was about £90 million. Abolition of this discretionary share option scheme was announced by the Conservative Chancellor, Kenneth Clarke, in response to the recommendations of the Greenbury Committee report, which argued that there was no case for one form of remuneration to receive preferential tax treatment over any other.[70] However, the scheme was not abolished but was replaced by company share option plans, a similar but less generous scheme.

Before any further changes are made to this area of the tax system, there are several questions that need to be answered. Is there any evidence that the existence of discretionary share option schemes in the past led to a greater movement in the highly skilled work-force? Or did people simply shift some of their income out of salaries and into share options in order to achieve a deferral (and potential avoidance) of tax?

6.6 Competition policy and regulation

It has long been debated whether firms with market power have better incentives to innovate. In the discussion above, we argued that granting firms market power after innovating is important in generating incentives to innovate. However, having market power prior to innovating may not be: competition may provide firms with greater incentives for technological and organisational innovation.[71]

There is clearly a role for government in preventing abuses of market power. Competition policy and regulation directly address static and dynamic efficiency. It is important that competition policy is flexible enough to be appropriately applied in industries that undergo rapid technological change. Competition legislation aims to maintain competitive markets and prevent firms abusing dominant positions. The aims of utility regulation are to introduce competition where possible, and where necessary to control prices and ensure consumers' needs are met.

Competition legislation to be introduced in the year 2000 adopts a prohibition approach in dealing with restrictive agreements and abuses of a dominant position in line with EU competition law, introducing fines of up to 10 per cent of turnover, and gives greater powers to the Office of Fair Trading. Not all parts of the existing legislation are being reformed — for example, the merger provisions will remain.

Here, as with most regulation, concerns arise with regard to compliance costs for firms, and in particular whether regulations will affect small and medium-sized enterprises disproportionately. These and other welfare costs should be taken into account when designing new regulations.

Globalisation and the growth of multinational firms make it more difficult for national governments to administer and enforce regulation effectively. It might be argued that

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[70]Inland Revenue press release IR149/95, 17 July 1995, 'Withdrawal of tax relief for approved executive share option schemes'.

[71]Although this would seem to be conditional on the extent to which firms face financing constraints.

some form of co-operation or a supra-national competition authority is necessary to minimise the burdens on firms whose cases would otherwise be dealt with under multiple national competition regimes. Sometimes, competition concerns do arise at a national level, and under EU competition law such cases can be 'repatriated'.

Regulations may have effects on productivity that go beyond compliance costs for business — for example, they may restrict entry to certain industries or geographical areas. Instead of attributing any under-investment in capital or skills to market failures, the recent report by McKinsey[72] emphasises market distortions as the root cause. The report highlights the impact of product and land-use regulations on economic efficiency. When considering whether regulations such as those on planning should be loosened as a means of improving productivity, it is important to recognise that we would be trading off social and environmental objectives, which also affect welfare. Making decisions on land use at regional and local levels may be the best way of reflecting the preferences of the parties who live in the areas affected.

Product market regulation such as safety standards may affect innovation — for example, by restricting entry or by altering the nature of competition between existing firms. Again, such regulations (for example, regulatory approval for pharmaceutical products) are in place for a reason, and their removal, even if it improves some measure of economic efficiency, will not necessarily improve welfare.

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[72] McKinsey Global Institute, 1998.

7. Conclusion

This Commentary has questioned whether Britain faces a productivity gap with the US, or whether lower levels of output per worker reflect the fact that we use fewer inputs. Historically low levels of investment suggest that our stocks of R&D and physical capital are low. Taking into account differences in hours worked and in the quality of our inputs, we see that our productivity gap with the US is significantly lower than that suggested by the government's figures.

The Pre-Budget Report considers several policy options open to the government. These are largely aimed at increasing the incentives for small firms to invest in both R&D and physical capital. Some of these policies may have merits in their own right, but they are unlikely to lead to large-scale increases in investment or productivity levels in the near future, since the small firms at which they are targeted do not account for a large share of investment. If we do not face a large productivity gap with the US, but rather have lower levels of investment, then policies to correct these shortfalls could take a long time to have an impact.

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