

# Accounting for UK economic performance 1973-2009

Ray Barrell, Dawn Holland and Iana Liadze<sup>1</sup>

National Institute of Economic and Social Research

*Abstract:* Economic performance in the UK improved over 1997 and 2007 in comparison to other OECD countries. We employ growth accounting and cross-country regression analysis to identify factors behind this relative improvement in performance. Based on growth accounting analysis, we find out that, capital deepening and skills improvements, as well as financial services constitute a small part of the improvement in hourly productivity performance. The majority of the improvement comes from factors affecting the level of technology and the efficiency of factor use. Our results from regression analysis, support this conclusion and suggest that improvements in efficiency from increased openness and foreign direct investment are the most important components behind productivity change.

JEL Classification E22, O43, O47

Key Words Growth accounting, skills, productivity, technology, convergence

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## Introduction

Up until the onset of the financial crisis, UK performance looked better than that of many other European countries. There are many ways to decompose the factors behind this better performance, and we compare two approaches, both of which are related to an evaluation of input quantity and quality. The first involves the use of growth accounting, and the second the estimation of a cross-country panel regression. We have combined these approaches previously in Barrell, Holland, Liadze and Pomerantz, (2007) and in Barrell, Holland, Liadze and Pomerantz (2009), but for a different set of countries over a shorter period, and hence our work extends our previous discussions.

Both approaches start with the assumption that output growth depends upon the growth of labour and capital inputs and on the rate of growth of technical progress. However, it is useful to separate labour input (or the level of technical progress) into a quantity and a quality component. Barrell, Holland, Liadze and Pomerantz (2007) undertook a preliminary version of this using data on skill composition and skill rewards across a number of countries. We adopt a similar approach for a sample of 12 OECD countries, covering the 35 year period to 2007. Our choice of countries was determined by data availability, especially in relation to skills indicators.

Growth accounting on basic price income data is performed for labour hours, labour quality and capital inputs, and hence a true Total Factor Productivity (TFP) residual is calculated. This allows us to decompose growth into a component driven by capital deepening, one by raw labour input, and another by labour quality as measured by a Tornqvist based measure of workforce skills. The residual is attributed to total factor productivity growth. This analysis allows us to make a first evaluation of the impact of reforms in education and training in the UK over the last 20 years and to discuss the relationship between the timing of TFP changes and policy innovations such as competition legislation and product and labour market reforms. We also investigate in passing the potential impact of the growth of financial services in the run up to the crisis. Growth accounting allows us to separate out the impact of capital deepening on labour productivity from skills and TFP effects. A more formal analysis of the factors affecting TFP is needed and this is undertaken in the second approach.

The second approach is essentially a variant of the cross-country panel regression framework developed by Barro (1991). The cross-country panel regressions relate output per person hour to our measure of workforce skills and a series of factors that are thought to drive the rate of technical progress, such as research and development,

openness to innovations from abroad through trade and foreign direct investment, as well as heightened competition brought about by the removal of trade barriers. We also look at the impact of banking crises on labour productivity. We address the issue of the impact of financial crises on the sustainable level of output, and note that only for around one in four crises is there any evidence that there has been a permanent scar. However, the current crisis is likely to leave a permanent scar on almost all economies.

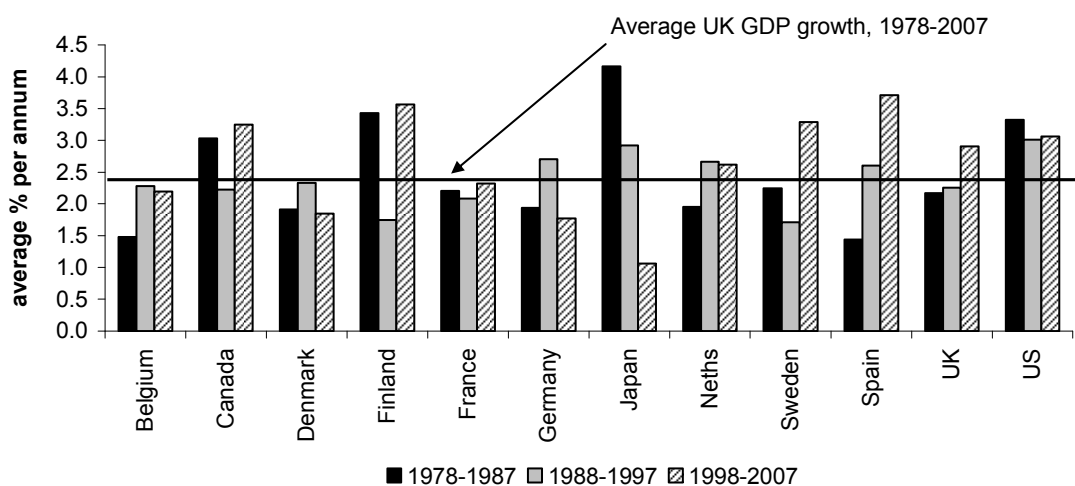
All estimation extends to 2007, and we then analyse the response to the banking sector induced recession and the impact on output in order to evaluate the robustness of institutions against a strong downturn. This must be undertaken in a comparative context, and we use the same group of countries throughout. It is not clear that institutions in the UK have been robust against the crisis, although we must distinguish between the short and the long term impact. In particular the fiscal and monetary response could have been more robust, but there are many factors that pattern the short term response to the crisis. We draw on Barrell and Holland (2010) to help explain differences in the depth of the crisis. Labour market institutions in the UK appear to be more able to absorb this shock than in the past, as Holland, Kirby and Whitworth (2010) suggest. The financial sector is likely to shrink in all economies, and the impact on the UK may be larger than in most other countries, as it has a larger share in activity. However, apart from this, there is no strong reason to suggest that the long term impact on the UK will be particularly larger than other countries, although the recession has been more severe than in many. The crisis has been global, and risk premia are likely to rise by similar amounts everywhere, and impacts on sustainable output will also be similar, and we suggest that output per person hour in the UK will be permanently 3 per cent lower than we had anticipated in early 2008.

## **Overview of the UK growth performance**

Up until the onset of the financial crisis, output growth in the UK exceeded that in many other European countries. GDP at basic prices increased at an average annual rate of 2.4 per cent per annum in the thirty years from 1978-2007, with somewhat stronger growth in the final decade. Figure 1 illustrates the UK growth performance relative to the other 11 OECD economies covered in this study. UK growth has not been as rapid as in the North American economies, although these differences narrowed sharply in the final decade of our sample to 2007. Within the European Union, growth has recently been faster in Finland and Sweden, and for the last two decades also in Spain, while the UK growth performance compares favourably to the

rest of the countries in the sample. Over the last period growth accelerated in the UK, Sweden, Spain, Finland and Canada noticeably, and it was approximately constant in the US, the Netherlands, Belgium and France, whilst it decelerated in Denmark, Germany and Japan. Our objective is to evaluate the factors that may have driven this relative improvement in UK economic growth.

**Figure 1: UK GDP growth (basic prices) in perspective**



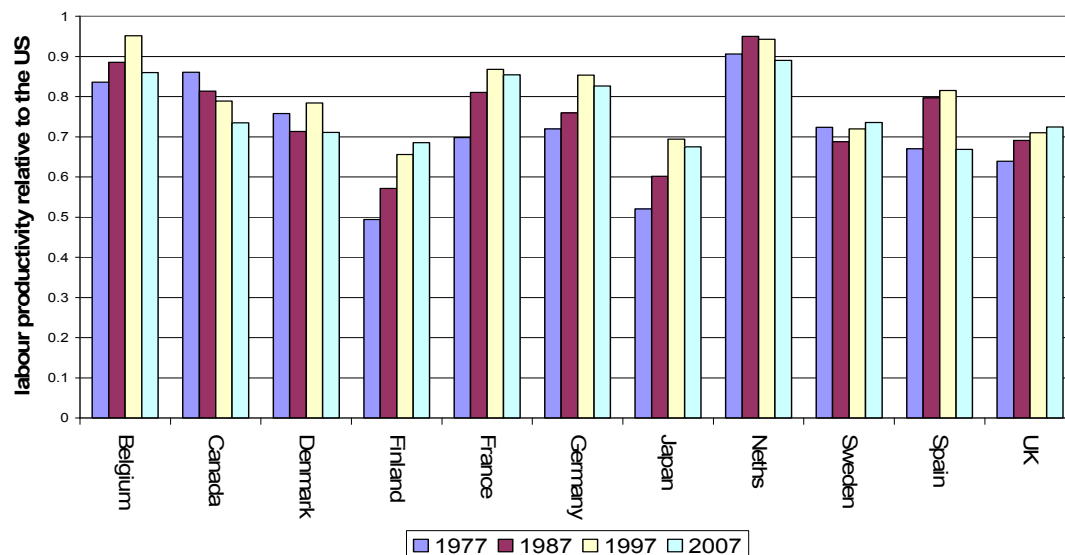
There are many reasons why growth might accelerate in some countries and not in others. Structural reforms that increase efficiency of factor use, improvements in technology and increases in the quantity or quality of factors of production are the three obvious categories to look at. We should also look at the level of productivity per person hour to see how far countries are from the efficiency and technology frontiers, and we do that in Figure 2 which plots productivity in 2005 PPPs relative to the USA for each of our start or end years. In no year does any country in our sample (and with our PPP base in 2005) have productivity per person hour higher than that in the USA, and hence we can regard this as our frontier. We would expect other countries to generally catch up with the US, but it is not clear that this has been happening.

In 1977 UK productivity per person hour, which is the dependent variable in our second approach, was lower than most of the other countries studied here, and higher only than that in Finland and in Japan<sup>2</sup>. The UK and Finland are the only countries where productivity relative to the US rises over each interval, and productivity in the UK, Finland and Sweden rises relative to the US over the last period we consider. On the basis of growth and improvements in the level of productivity UK performance

<sup>2</sup> It is likely that hours worked were systematically underreported in Spain over this period, and it also has a much lower participation rate than other countries included here, and hence only the most productive workers are recorded as in employment.

looks better than most countries we consider in the decade from 1997 to 2007, and we can evaluate the reasons for this.

**Figure 2: Relative levels of productivity (USA=1.00, 2005 PPPs)**



It is common to describe the productive capacity of an economy through the use of an aggregate production function, which describes the interaction between factor inputs, such as labour and capital, the state of technology, and any other factors that may affect the quality or efficiency of the production process. Growth may vary across countries because factor input growth differs over time and space. Labour supply depends on institutions, preferences and demographics, and its equilibrium will change when the structures of these institutions, preferences and demographic change. Capital input growth may also differ over time either because investment growth changes or because the rate of depreciation of the existing capital stock changes. The productive capacity of factor inputs depends on their innate quality, for example driven by the skill level of the workforce, and on the technology used to combine factor inputs, which may depend on the domestic research base as well as access to innovations developed abroad.

### *Factor Inputs,*

Labour market reforms and their effects on participation and equilibrium unemployment are likely to increase equilibrium output, but they are not necessarily drivers of technical progress, except to the extent that they change rent seeking behaviour. These reforms mainly affect the supply of labour, and it is difficult to separate out their effects in our growth accounting and econometric work. Output also depends upon the quantity of capital available, and increased competition and the

reduction of barriers may increase the efficiency with which capital is used, and there may be capital flows from low return to high return regions. In addition the quantity of capital may increase if savings globally rise or the user cost of capital displays a downward trend, and these two factors may be related. The user cost of capital may trend down because increased saving puts downward pressure on real interest rates, because policy and innovation reduce risk premia or because financial innovation reduces the cost of intermediation and hence the margin between borrowing and lending rates. All of these are discussed in Barrell et al (2009). Trends in user cost and other factors affecting capital deepening may continue for a long period, but the gains may be illusory, as we may have discovered in the recent financial crisis. Specific effects of financial crises are hard to track down, but they will sometimes induce a re-evaluation of risk premia on investment and reduce the equilibrium capital stock and hence the equilibrium level of sustainable output.

#### *Market Efficiency and Technical Progress*

There are a number of factors which affect overall productivity, and these may be grouped into the efficiency with which factors are used, the level of scientific knowledge available to complement capital and labour, and the skills and training of the workforce. General purpose technical progress may be a common pool resource driven by public good scientific research and general innovation, and it is likely to be similar across countries. However, institutions may speed up or even prevent the absorption of new ideas.

Openness to trade is thought to have important effects on productivity growth. The ability to trade enables a country to specialise in more efficient production processes raising the aggregate growth rate temporarily. Endogenous growth models have also pointed to the possibility that contacts with the outside world may potentially raise the growth rate permanently (see, for instance, Coe and Helpman, 1995; and Proudman and Redding, 1998). There is evidence that increases in competition brought about by the removal of trade barriers raise output, and we draw attention to the single market programme (ESM) as a factor affecting a number of our countries, which would capture both the increase in trade as a result of the changing nature of goods and also the conscious attempts to increase competition by removing barriers. There may also be country specific competition policy factors that we should take into account, and country specific policies toward research may be important in explaining differences in growth.

Endogenous growth models have been developed by Aghion and Howitt (1998) and others where R&D expenditures or the number of researchers drive the growth

process. Griffith et al. (2004) discuss the two faces of R&D. Not only does R&D increase the innovation rate in the technology frontier country, but it also raises the absorptive capacity of an economy to new ideas. Hence in our econometrics below we use an estimate of the stock of R&D as an indicator of usable knowledge, based on the accumulation of flows of R&D onto a depreciating stock<sup>3</sup>.

### *Skills*

Our growth decomposition and regression studies separate the quantity of labour input into the production process from the quality of labour input. Quantity measures of the level of employment and average hours of working time per employed person are readily available. However, quality measures are more difficult to estimate, as for our purposes skills cannot be measured independently of their usefulness. We need to be able to distinguish broadly comparable types of labour across countries, with differing levels of education. In addition we need to be able to estimate their value in the production process, and perhaps the best way to do this is to use relative wages as an indicator of the relative productivity of the workforce. We would want skills in the economy to increase with an increase in the proportion of those with a higher skill level. We would also want the quantum of skills to increase if the skills acquired became more productive, either because the skills had improved, or technical change had made them more useful. We therefore choose to measure skills by wages (marginal products) relative to the unskilled. This is perhaps problematic as the unskilled are not completely unskilled in any of our countries, and they have degrees of numeracy and literacy that change over time, changing their productivity. However, setting them to 1.0 is the least bad option we have to index skills<sup>4</sup>.

We adopt a Tornqvist discrete time version of a Divisia index to construct an indicator of workforce skills. The EUKLEMS<sup>5</sup> database contains information on the skill mix of a large group of the OECD member countries. In particular data on hours worked by persons engaged and compensation of the workforce in low, medium and high skill category groups are available. First, a relative compensation for each skill group over

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<sup>3</sup> We use OECD data on gross expenditures on R&D for the whole economy. We benchmark the stock before the beginning of our data period as the flow divided by the average growth rate and the depreciation rate, and we cumulate flows onto this stock with a depreciation rate of 15 per cent.

<sup>4</sup> We measure skills by their market value, as it allows skill destruction as well as acquisition. Hargreaves Spinning Jenny destroyed the market value of the skills of hand spinners, much as Cartwright's power loom destroyed the market value of the skills of hand loom weavers

<sup>5</sup> The EU KLEMS Database was the result of a large scale collaborative project between European researchers on productivity financed by the European Commission, and is available at <http://www.euklems.net>.

time was calculated.<sup>6</sup> Based on the assumption that relative wages reflect relative marginal product, skill premiums for medium and high skill groups are calculated relative to the low skill category. A Tornqvist index<sup>7</sup> is then calculated as:

$$\ln(TQ) = \sum_{j=1}^3 S_{jt} (\ln x_{jt} - \ln x_{j,t-1}) \quad (1)$$

with  $S_{jt} = 0.5(S_{jt} + S_{j,t-1})$

where TQ - Tornqvist index,  $S_{jt}$  – share of hours worked in each skill category and  $x_{jt}$  – skill premium for each group. Once the Tornqvist index is created, it is applied to the initial value of total hours worked and the skill index is calculated as a relative value in each year as compared to the first available year of observations<sup>8</sup>. Given our assumption that wage differentials reflect underlying productivity differentials we constructed an index of efficiency units of labour for each country, with a higher value of the index implying a higher level of knowledge embodied in workers, which raises productivity of labour.<sup>9</sup>

There are common trends across all countries in both compensation shares and hours worked by less skilled workers and increasing share of hours worked and compensation received by high skill employees. However, the relative speed and size of the change in all shares and their combinations lead to different time patterns of skill indices in the countries. The Tornqvist skill index rises over time in Canada, Germany, Netherlands, the UK and the US, with the largest increase in the US followed by the UK. In all these countries, to a different extent, we have seen a change in the skill mix of the workforce over the sample period. The share of hours worked and total compensation of high skilled workers have risen, with an increase in the share of compensation for high skilled workers outstripping the growth in the hours worked. The middle skilled group on average maintained a constant share in both hours worked and compensation, while the low skilled group has seen both shares falling. Increases in compensation for high skilled workers resulted in a rise in the high skill premium which has a positive effect on our indicator of skills which is based on the assumption that higher wages indicate higher productivity.

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<sup>6</sup> The relative wage is the share of total compensation received by a skill category divided by the share of total hours contributed by the same group.

<sup>7</sup> This is a weighted sum of the growth rates of the various components, where the weights are the component's shares in total value

<sup>8</sup> Where the skill premium is absent or unreliable we have calculated it by applying the average annual change over the 9 preceding years to the previous year's data. A number of countries lack data in 2006 and 2007, and the UK and France have data from 2004 and 2003 respectively that we consider unreliable..

<sup>9</sup> Where data is absent we assume constant shares of skill categories.

Belgium, Denmark, Spain and Sweden do not display too much variation in the skill index. In all four countries there is a slight decrease in relative wages and skill premiums for high and middle skill category groups. But while in Belgium and Denmark an increase in the working hours of the middle skill group workforce accompanied an increase in the share of compensation in the same category group, in Sweden we hardly see any change in these variables. Spain has undergone the most dramatic change; by moving from a labour market dominated by low skilled workers to a skill split with highly compressed wages. The next section outlines the principles of growth accounting and uses empirical estimates to compare TFP growth and capital deepening across countries.

## Growth accounting

Robert Solow (1957) is generally attributed with the introduction of the theoretical framework for growth accounting. Solow's framework specifies an explicit model of potential output as a function of factor inputs, such as capital and labour, and an efficiency indicator termed total factor productivity (TFP)<sup>10</sup>. This approach assumes a general underlying production function that maps the factor inputs to final output, thereby representing the productive capacity of an economy. With two factors of production this can be expressed as:

$$Y = f(K_t, L_t, T_t) \quad (2)$$

where  $Y$  is the final output good,  $K$  is the capital stock,  $L$  is labour input and  $T$  indicates the state of technology, or TFP. Totally differentiating this equation with respect to time, and assuming perfect competition in factor markets and a homothetic production function, the partial derivatives of the production function may be rearranged to obtain a decomposition of the growth rate of output into the sum of the growth rates of each input, weighted by their relative factor share, plus the growth in TFP.

$$d \ln(Y_t) = \theta_{K_t} d \ln(K_t) + \theta_{L_t} d \ln(L_t) + dA_t \quad (3)$$

Where  $\theta_{K_t}$  is the share of output accruing to capital,  $\theta_{L_t}$  is the labour share and  $dA_t$  is the growth rate of TFP, defined as:

$$dA_t = \frac{f_{T_t} T_t}{Y_t} d \ln(T_t) \quad (4)$$

We have assumed constant returns to scale, and hence  $\theta_{L_t} = (1 - \theta_{K_t})$ . Growth accounting exercises based on measures of physical units of capital and labour do not

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<sup>10</sup> Other terms for the indicator are Solow residual, measure of ignorance, or rate of technical change.

allow us to say whether changes in TFP capture efficiency gains in the production process achieved thanks to the implementation of technological innovations or whether they reflect changes in the quality of capital or labour. More can be learned from growth accounting using measures of the quality of the capital and labour input. Skills-adjusted labour input ( $L$ ) can be expressed as:

$$L = E * Hours * S \quad (5)$$

where  $E$  is total employment,  $Hours$  is average hours worked and  $S$  is a measure of workforce skills or human capital. The basic growth accounting decomposition can then be expressed as:

$$d \ln(Y_t) = \theta_{K_t} d \ln(K_t) + (1 - \theta_{K_t}) d \ln(E_t * Hours_t) + (1 - \theta_{K_t}) d \ln(S_t) + dA_t \quad (6)$$

A common growth accounting practice is to subtract the growth rate of (unadjusted) labour input from both sides of equation (6), to derive a decomposition of labour productivity into its components:

$$d \ln\left(\frac{Y_t}{E_t * Hours_t}\right) = \theta_{K_t} d \ln\left(\frac{K_t}{E_t * Hours_t}\right) + (1 - \theta_{K_t}) d \ln(S_t) + dA_t \quad (7)$$

The equation above indicates output per person hour can be decomposed into the contribution from skills accumulation, a contribution from capital deepening, which is the units of capital per hour worked, and the residual category, total factor productivity. In table 1 we use the simple relationship between output, labour input and labour productivity:<sup>11</sup>

$$Y = (E * Hours) * \frac{Y}{(E * Hours)} \quad (8)$$

in order to decompose GDP growth in to the contribution from labour input ( $E*Hours$ ) and labour productivity, defined as output per person hour. We then decompose labour productivity growth into the contribution from capital deepening, the contribution from skills accumulation and the residual component, total factor productivity growth. We look at three 10 year time periods from 1978-2007 in order to assess whether the contributions of various components have shifted over time. Results are reported for 12 OECD economies.

Averaged over the full 30 year sample period, GDP growth (calculated at basic prices in order to abstract from the impact of indirect taxes and subsidies on the measured level of income) was highest in the US, closely followed by Finland, Canada, Japan and Spain. GDP growth in Belgium, Denmark, Germany and France has been less

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<sup>11</sup> Details of sources are included in an appendix

robust on average. The average growth rate for Japan is biased by very strong growth in the earliest decade, while average annual growth in the 1998-2007 period was lower in Japan than in any other country in this sample. Conversely, the strong growth in Spain is driven by the very strong growth averaging 3.7 per cent per annum in the most recent decade, while earlier periods were less impressive.

Of the faster growing economies, the performance in the US, Canada and Spain can be largely attributed to strong growth in labour input, while labour productivity growth in these economies was closely in line with (or lower than in the case of Canada) the others in the sample. Japan and Finland, on the other hand, can attribute their strong growth performance to rapid growth in labour productivity. France, Germany and the UK have also exhibited relatively strong growth in labour productivity on average.

Skill accumulation has had an important impact on growth over the last thirty years in the US, Canada and the UK, and to a lesser extent Germany and the Netherlands. In the most recent decade, skill accumulation has raised growth in the US by about 1 percentage point per annum, and by about  $\frac{1}{2}$  per cent per annum in the Netherlands and Finland. Elsewhere the contribution from skills has been less significant.

Capital deepening has contributed more towards growth in France, Japan and Spain over the last 30 years than elsewhere, while it has been of less importance in Denmark and the US. Over the most recent decade, capital deepening played a more important role in the US, possibly reflecting the low costs of borrowing for investment in the period leading to the global financial crisis. In most of the other countries in our sample and especially in Spain and Japan, on the other hand, the contribution of capital deepening to growth diminished relative to the previous two decades.

What remains is the unexplained component of labour productivity growth, TFP. TFP growth has been particularly rapid in Finland, and has also risen rapidly on average in Japan and Sweden. In the most recent decade, TFP, after accounting for skills, has increased at an average rate of 1.6 per cent per annum in the UK, performing better than most of the other countries in this sample. Only Sweden and Finland had higher TFP growth in this period, reflecting the pace of technical change in specific industries such as telecommunications in which these small countries specialise. They also underwent extensive product market reforms in the early 1990s and may have gained from membership of the EU in 1995. The improvement in UK performance is clear over this period, and we can turn to look at developments in more detail.

**Table 1: Growth Decomposition**

		percentage point contribution to average annual GDP growth											
		Belgium	Canada	Denmark	Finland	France	Germany	Japan	Neths	Sweden	Spain	UK	US
<b>GDP at basic prices (% change)</b>	1978-1987	1.5	3.0	1.9	3.4	2.2	1.9	4.2	2.0	2.2	1.4	2.2	3.3
	1988-1997	2.3	2.2	2.3	1.7	2.1	2.7	2.9	2.7	1.7	2.6	2.3	3.0
	1998-2007	2.2	3.2	1.8	3.6	2.3	1.8	1.1	2.6	3.3	3.7	2.9	3.1
<i>of which</i>													
<b>Hourly labour input (unadjusted)</b>	1978-1987	-0.7	2.0	0.9	0.3	-0.9	-0.2	1.0	-0.1	1.2	-1.9	-0.2	1.7
	1988-1997	-0.1	0.9	-0.3	-1.3	-0.2	-0.1	-0.2	1.1	-0.4	0.7	0.3	1.4
	1998-2007	1.2	1.9	0.8	1.0	0.4	0.1	-0.7	1.1	1.0	3.7	0.6	1.0
<b>Output per person hour</b>	1978-1987	2.2	1.0	1.0	3.1	3.1	2.2	3.1	2.1	1.1	3.4	2.4	1.6
	1988-1997	2.4	1.3	2.6	3.0	2.3	2.8	3.1	1.5	2.1	1.9	1.9	1.6
	1998-2007	1.0	1.3	1.0	2.5	1.9	1.7	1.8	1.5	2.3	0.0	2.2	2.0
<i>of which</i>													
<b>Skills accumulation</b>	1978-1987	-0.1	0.1	0.0	-0.4	-0.2	0.4	-0.3	-0.4	-0.3	-0.2	0.7	0.5
	1988-1997	-0.1	0.9	-0.1	0.0	0.2	0.3	-0.1	0.6	0.1	-0.1	0.7	0.9
	1998-2007	0.0	0.3	0.2	0.5	-0.2	0.0	-0.2	0.5	0.0	0.0	-0.1	1.0
<b>TFP (excluding skills)</b>	1978-1987	1.4	0.3	0.6	2.5	1.8	0.8	2.3	1.7	1.0	1.9	1.0	0.8
	1988-1997	1.6	-0.4	2.2	2.2	1.0	1.5	1.6	0.6	1.1	0.8	0.6	0.4
	1998-2007	0.7	0.6	0.7	1.7	1.3	1.2	1.4	0.5	2.0	-0.3	1.6	0.4
<b>Capital deepening</b>	1978-1987	0.8	0.5	0.3	0.9	1.5	0.9	1.1	0.8	0.4	1.7	0.6	0.3
	1988-1997	0.9	0.6	0.5	0.9	1.2	1.0	1.6	0.4	0.9	1.2	0.6	0.3
	1998-2007	0.3	0.4	0.2	0.2	0.8	0.6	0.5	0.4	0.2	0.3	0.7	0.6

**Figure 3: TFP growth in the UK and regulatory reform**

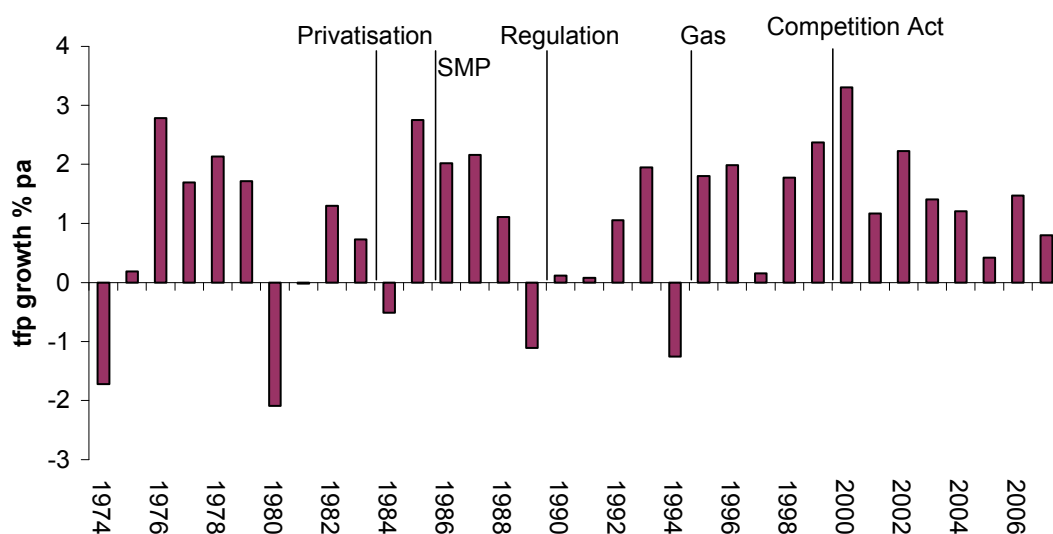


Figure 3 plots the growth of TFP on a year by year basis. We mark the five most important events in the process of attempting to improve the efficiency of factor use in the UK over our time period. The first is the start of the privatisation programme in 1984 which was based on a belief that private share ownership was sufficient to ensure that productivity would improve without any concern for the regulatory framework or competition environment in which privatised firms were placed. As a result private sector monopolies with inflexible pricing rules were set up, and efficiency did not improve as much as might have been expected. The second is the beginning of the Single Market Programme (SMP) in 1986, which was a programme that removed barriers to competition in Europe. Its impact is discussed at length in Barrell et al (2009), and it is clear that it had an impact on sustainable output by improving competitive forces. The first electricity privatisation in 1990 was better designed to raise productivity, with some recognition that competition mattered, but it was only with the restructuring of the gas industry in 1995 that the benefits of privatisation were beginning to be available.

The gradually changing attitude to competition became clear by 1998, with a new competition act (effective from 2000) where for the first time cartels became illegal, and it was clear that the framework was designed in the interest of the consumer. This approach to market based regulation was almost certainly a factor behind the increase in TFP growth from the mid 1990s, and it can be considered a success. However, 'light touch' regulation had its problems, and it was certainly a factor behind the growth of the financial services sector from the mid 1990s, and probably contributed to the crisis we have seen in the last three years.

**Table 2. Growth decomposition 1998-2007**

	percentage point contribution to average annual GDP growth											
	Belgium	Canada	Denmark	Finland	France*	Germany	Japan**	Neths	Sweden***	Spain	UK	US
GDP at basic prices (% change) of which	2.2	3.25	1.85	3.56	2.1	1.77	0.8	2.62	3.2	3.71	2.9	3.06
Contribution from financial intermediation	0.24	0.24	0.34	0.01	0.18	0.01	0.10	0.25	0.19	0.45	0.39	0.40
Contribution from other sectors	1.95	3.01	1.51	3.55	1.92	1.76	0.7	2.36	3.01	3.26	2.51	2.66
Growth in production in financial intermediation of which	3.95	3.92	6.43	1.16	3.69	0.1	1.46	3.7	4.06	9.46	6.13	5.17
Employment	2.23	1.99	0.73	0.61	1.77	0.17	-1.52	0.97	0.58	3.54	0.88	1.53
Output per person	1.69	1.89	5.66	0.55	1.88	-0.07	3.02	2.71	3.45	5.72	5.2	3.58
Share of financial intermediation (2000)	0.060	0.060	0.047	0.045	0.051	0.042	0.058	0.061	0.045	0.046	0.051	0.076
Hourly productivity growth in financial intermediation	1.70	2.08	5.22	0.90	2.50	0.45	3.64	2.87	3.74	6.31	5.54	3.79
Whole economy productivity	1.02	1.31	1.05	2.49	1.65	1.71	1.82	1.45	2.28	0.04	2.24	2.04
Implied productivity growth in res	0.97	1.27	0.84	2.57	1.61	1.76	1.71	1.36	2.22	-0.26	2.07	1.90
Financial sector contribution to productivity	0.04	0.05	0.21	-0.07	0.05	-0.05	0.11	0.09	0.07	0.30	0.18	0.14

\* Sample period for France is 2000-2007

\*\* Sample period for Japan is 1997-2005

\*\*\* Sample period for Sweden is 1999-2007

The change to the competitive environment in the UK had been largely completed by 2002, with only minor improvements thereafter. Part of the changed environment for competition involved reduction in the complexity and stringency of regulation, and this included financial regulation. It was widely believed that light touch regulation in this sector would enhance the UK's attractiveness as a location for financial intermediation, and hence enhance output and productivity growth. The contribution of the financial services sector to productivity growth is analysed further in table 2 for the last decade, as data are not easily available for earlier periods for all countries. We calculate productivity growth in this sector (on the assumption that trends in hours were the same as elsewhere) and compare it to the implied productivity growth in the rest of the economy outside this sector. The weighted average of these two growth rates gives whole economy growth. The impact of the financial sector on overall productivity growth is taken to be the excess (or in two cases shortfall) of the sectors productivity growth as compared to the rest of the economy multiplied by the size of the sector. In the UK for instance productivity growth outside financial intermediation was 2.07 percent a year, whilst it was 5.54 percent a year in inside the sector. Hence excess productivity growth in the sector was 3.47 percent a year, and in 2000 the sector represented 5.1 per cent of the economy. Hence the contribution to growth was 0.18 percentage points ( $3.57 \times 0.051$ ).

Growth in the financial sector contributed most in Spain, the US, the UK and Denmark, and in most countries productivity growth was more rapid in this sector. The additional contribution to productivity growth from the sector averages 0.1 per cent per annum across all countries, and was almost 0.2 per cent per annum on average in the UK, and hence it is a partial explanation of why productivity in the UK grew more rapidly. However, removing this addition from all countries leaves rankings unchanged, as the deduction is lower in Finland and Sweden, the only countries ahead of the UK. Germany moves toward the UK.

Our growth accounting work suggest that capital deepening and skills improvements were only a small part of the set of reasons for the improvement in hourly productivity performance in the UK over the period 1997-2007. The same might be said of the impact of financial services. The majority of the improvement came from factors affecting the level of technology and the efficiency of factor use. We next consider an approach that will allow us to look at the factors that have affected this improvement in underlying TFP.

## Regression analysis

In the previous section we used a growth accounting approach to look at the decomposition of annual GDP growth and its components. We discussed factors affecting change in labour productivity, which we were able to split into growth in skills, TFP and capital deepening. In this section we analyse in more detail the forces driving change in labour productivity and specifically consider breaking down the determinants of TFP further into possible components, and we attempt to identify two groups of factors associated with improvements in technology and improvements in the efficiency of factor use.

In the section above we discussed the determinants of labour productivity, which we may denote as  $y = Y/EH$  where  $Y$  is output in basic prices,  $E$  is employment and  $H$  are hours per person in employment. We can separate the determinants into capital deepening, which we may denote  $k$ , skills, which we have denoted as  $s$ , and the two factors driving TFP, technology which we denote as  $t$ , and efficiency which we denote as  $x$ . We can then write and evaluate (9) which is the relationship between labour productivity and the factors driving it through their impact on capital and technology. Labour productivity per person hour can be expressed as:

$$\ln(y) = F(k, s, t, x) \quad (9)$$

We use a number of different indicators and drivers of technology and efficiency. We avoid econometric estimation using the capital stock because of measurement problems, and instead look for effects from factors determining capital deepening as well as those that affect the cost of capital, such as risk premia driven by financial crises and the user cost of capital.

The technical progress term  $t$  may depend on a number of factors, including Research and Development (R&D) and openness and competition indicators. Furthermore, Foreign Direct Investment (FDI) as a proportion of GDP can reflect the creation of knowledge and/or ease of absorption of technical progress via direct import of frontier technology by foreign firms that local firms can imitate. There are also a number of indicators of the potential effects of more effective competition policy. The variable for the European Single Market (ESM) mirrors the official timing of the programme and starts in 1986 at 0 and gradually rises to 1.0 in 1993. Membership effect dummies (EU95, EU86) are introduced as well (which increase from 0 to 1 over three year period) to capture the gradual process of integration of a country into a member of the European Union. We also use a direct indicator of openness (OPEN) as measured by the sum of the volumes of imports and exports of goods and services as a ratio of real

output. We can write an equation that is linear in logs that includes these variables as the determinants of labour productivity

$$\begin{aligned} \ln(y_t) = & d_1 + d_3*\ln(k)_t + d_4*\ln(FDI/Y)_t + d_5*\ln(R\&D/Y)_t + \\ & d_6*ESM_t + d_7*\ln(OPEN)_t + d_8*\ln(SKILLS)_t + \\ & d_9*EU86_t + d_{10}*EU95_t + error_t \end{aligned} \quad (10)$$

We substitute out  $k$  and replace it with its determinants which we take to be the user cost of capital and bank crisis related risk premium indicators. We capture the long run impact of banking crises by introducing crisis dummies (which are 0 prior to the crisis occurrence and 1 thereafter). We include dummies only for systemic crises, although we test this assumption subsequently. The long run relationship can be written as follows

$$\begin{aligned} \ln(y_t) = & d_0 + d_3*\ln(user)_t + d_4*\ln(FDI/Y)_t + d_5*\ln(R\&D/Y)_t + \\ & d_6*ESM_t + d_7*\ln(OPEN)_t + d_8*\ln(SKILLS)_t + \\ & d_9*EU86_t + d_{10}*EU95_t + d_{11}*CRIS_t + error_t \end{aligned} \quad (11)$$

In order to establish whether there is a long run relationship between the variables, we run tests to find a cointegrating set for each country and then use it in the construction of a dynamic panel. The sets with the minimum number of variables are chosen based on the stationary properties of the variables. Augmented Dickey-Fuller (ADF) tests with an intercept<sup>12</sup> and a lag length of one (as data series are annual) are used to check for both the order of integration of variables and the presence of a unit root in the residuals from the estimated long run equations. ADF test results for variable stationarity reported in table 3 illustrate that we can treat all our variables as integrated of order one (I(1)) and thus use an error correction approach for productivity analysis.

**Table 3: ADF test results of variable stationarity**

	DLN(Y/EH)		Ln(Y/EH)		Ln(R&D/Y)		Ln(FDI/Y)		Ln(SKILL TQ)		Ln(OPEN)	
	level	1st diff	level	1st diff	level	1st diff	level	1st diff	level	1st diff	level	1st diff
Belgium	-3.882		-3.413	-2.697	0.267*	-2.848	-2.788	-3.391	-0.715*	-5.284	0.432*	-6.041
Canada	-3.996		-0.445*	-3.923	-1.563*	-2.922	-1.982*	-3.609	-1.205*	-3.309	-0.441*	-3.413
Denmark	-3.134		-1.635*	-3.814	0.02*	-3.541	0.566*	-3.758	-1.425*	-3.807	2.482*	-3.628
Finland	-4.984		-0.535*	-4.967	-1.572*	-3.841	-1.606*	-4.966	-1.068*	-2.443	0.901*	-3.879
France	-4.208		-2.759	-3.931	-2.31*	-2.358	-0.517*	-3.896	-1.374*	-4.102	0.652*	-4.167
Germany	-2.916		-2.018*	-2.661	-2.195*	-3.213	0.317*	-4.083	-1.469*	-3.285	1.725*	-3.748
Japan	-3.235		-2.852	-2.954	0.315*	-3.443	1.884*	-4.268	-0.681*	-3.832	2.067*	-4.407
Neths	-4.701		-2.149*	-3.648	-1.476*	-3.837	-1.728*	-4.063	0.461*	-1.521*	1.332*	-4.653
Spain	-2.046		-2.498*	-3.363	-0.898*	-2.556*	-3.37	-3.378	-1.071*	-1.967	-0.366*	-3.179
Sweden	-2.042		0.417*	-1.728	-2.581*	-3.622	0.028*	-3.966	-1.537*	-3.05	1.473*	-4.234
UK	-5.026		-0.862*	-5.024	-1.431*	-3.577	-2.288*	-4.939	-0.984*	-3.318	1.038*	-3.917
US	-4.372		-0.247*	-3.635	-0.899*	-3.755	-1.25*	-3.286	0.623*	-4.128	0.275*	-4.06

Note: \* indicates less than 90% significance level

The first two columns are for productivity per person hour

<sup>12</sup> There are several cases when variables are difference stationary without an inclusion of an intercept.

A minimum cointegrating set is derived separately for each country. All relevant variables are included with output per person hour as the dependent variable. All insignificant variables were eliminated. The residuals of the resulting equations were checked for the presence of a unit root. If the unit root test is not passed then different combinations of the variables were checked until a stationary set was found. Results from the cointegrating analysis in Table 4 show that all equations for all countries in the sample cointegrate, implying we have an acceptable specification. In no country is *user* a significant variable in the cointegrating set.

**Table 4: Cointegration of the long run**

Belgium	Canada	Denmark	Finland	France	Germany	Japan	Neths	Sweden	Spain	UK	US
-6.232***	-3.915*	-4.624***	-5.633***	-3.811**	-4.055*	-4.224**	-3.702*	-3.554*	-3.496*	-4.014*	-3.577*

Note: \*, \*\*, \*\*\* represent significance at 90%, 95% and 99% levels correspondingly; data period 1973-2007

$$\begin{aligned}
 D\ln(y)_t = & d_1 + d_2*(\ln(y)_{t-1} + d_3*\ln(user)_{t-1} + \\
 & d_4*\ln(FDI/Y)_{t-1} + d_5*(R\&D/Y)_{t-1} + d_6*ESM_{t-1} + d_7*\ln(OPEN)_{t-1} + \\
 & d_8*\ln(SKILLS)_{t-1} + d_9*EU86_{t-1} + d_{10}*EU95_{t-1} + d_{11}*CRIS_{t-1}) + \\
 & d_{12}*D\ln(y_{t-1}) + error_t \quad (12)
 \end{aligned}$$

We then use the minimum cointegrating set in the context of a simple error correction framework as in (12). We use the Common Correlated Effects (CCE) (Pesaran, 2006) method for estimation, where Ordinary Least Squares (OLS) is applied to the system of error correction equations, with averages of the independent variables as well as the dependent variable added to each country's specification. The CCE method is employed given the possibility of heterogeneity in our group of countries and probable existence of common unobserved factors omitted from the panel causing parameters to be biased. Of particular relevance is the inclusion of productivity per person hour, the long run dependent variable, as a common factor. This is calculated in PPP units to ensure comparability across countries and it should pick up any common productivity trend.

The general to specific approach is applied to the panel of variables, where the least significant variable was eliminated and the regression is then repeated. The exclusion process continued until only variables significant at least at the 90% level were left. The results from general-to-specific estimation with the variables to be included in the long as well as short run are reported in Table 5.

**Table 5: Estimation results**

	Belgium	Canada	Denmark	Finland	France	Germany	Japan	Neths	Sweden	Spain	UK	US
Error correction	-0.2 (0.000)	-0.26 (0.007)	-0.544 (0.000)	-0.57 (0.000)	-0.164 (0.003)	-0.217 (0.011)	-0.118 (0.008)	-0.26 (0.003)	-0.383 (0.000)	-0.213 (0.000)	-0.352 (0.001)	-0.251 (0.009)
Ln(FDI/Y)	0.013 (0.04)	0.12 (0.019)	-	-	0.09 (0.046)	-	-	0.078 (0.017)	0.071 (0.014)	0.031 (0.000)	0.066 (0.000)	0.097 (0.005)
Ln(R&D/Y)	-	-	0.249 (0.000)	0.463 (0.000)	0.411 (0.063)	0.317 (0.049)	0.58 (0.043)	-	-	-	-	-
Ln(Open)	-	0.175 (0.009)	-	0.098 (0.004)	-	0.153 (0.068)	-	-	0.249 (0.051)	-	0.457 (0.000)	-
European single market	0.119 (0.005)	-	0.112 (0.000)	-	-	0.129 (0.002)	-	0.065 (0.038)	-	-	-	-
EU membership 1986	-	-	-	-	-	-	-	-	-	0.113 (0.007)	-	-
Ln(Skill_tq)	-	-	-	-	-	-	-	-	-	-	0.349 (0.04)	0.715 (0.000)
Long run crisis effect	-	-	-	-0.029 (0.053)	-	-	-0.132 (0.032)	-	-	-	-	-0.063 (0.052)
Crisis date			1991	1991			1997					1988
DLn(Y/EH(-1))	-	-	-	0.413 (0.002)	-	-	-	-	0.461 (0.001)	0.449 (0.001)	0.403 (0.028)	-
AvLn(Y/EH)	0.085 (0.000)	0.085 (0.000)	0.085 (0.000)	0.085 (0.000)	0.085 (0.000)	0.085 (0.000)	0.085 (0.000)	0.085 (0.000)	0.085 (0.000)	0.085 (0.000)	0.085 (0.000)	0.085 (0.000)
AvDLn(Y/EH)	0.718 (0.000)	0.718 (0.000)	0.718 (0.000)	0.718 (0.000)	0.718 (0.000)	0.718 (0.000)	0.718 (0.000)	0.718 (0.000)	0.718 (0.000)	0.718 (0.000)	0.718 (0.000)	0.718 (0.000)

Note: Ln(FDI/Y) - natural log of the ratio of inward foreign direct investment to output; Ln(R&D/Y) - natural log of the ratio of stock of research & development to output; Ln(OPEN) - natural log of the ratio of sum of exports and imports to output; Ln(SKILLS) - natural log of Tornqvist based skills index; DLn(y) - difference of the natural log of output per person hour; AvLn(y) - unweighted average of the natural log of output per person hour; AvDLn(y) - unweighted average of the difference of the natural log of output per person hour; probabilities in parenthesis; estimation period 1974-2008

We organise the variables into three groups, along with skills and banking crisis indicators. We can see FDI and R&D as indicators of knowledge based technical progress that are specific to each country, whilst openness and the European indicators can be seen as efficiency pressures that are country specific. The common factor (CCE) variables capture the average level and average growth rate of productivity in our sample, and represent common trends in knowledge and efficiency as well as other common factors that might affect productivity per person hour. They are both highly significant in all countries, and have coefficients that are not particularly different from each other.

The different nature of technical progress and market competition across different countries is illustrated by each country having at least one indicator of technical progress that is significant in addition to the common “trend” variable. Foreign Direct Investment is significant and has a positive impact in 8 out of 12 countries in the sample. Increased globalisation and trade between countries facilitates FDI and through it the spread of technology and knowledge. R&D is significant in Denmark, Finland, Japan, Germany, and only marginally significant in France, but its significance may be clouded by the presence of an FDI effect, the only country where both occur. In all cases it has a positive sign, indicating that higher R&D enables these countries create technical progress more readily. The magnitude of the effect of R&D varies, with Japan showing the highest significant effect and Denmark the lowest. The US undertakes a lot of R&D but this appears to be absorbed in the common trend, and it is only in countries where creative rather than absorptive R&D takes place that we find an additional and positive effect from this indicator.

Efficiency indicators are present in all countries except France and the two largest economies, Japan and the US. Global integration (OPEN) is the most significant in the UK followed by Canada, Finland and then by Sweden and Germany. The European integration variables have a positive effect in Germany, Belgium, Denmark and the Netherlands, and the EU membership indicator suggests that joining the EU raised productivity levels in Spain by more than 10 percent. While there is no evidence of an R&D effect on productivity in the US and the UK, and no openness effect in the US, there is a strong and positive impact from the skills indicator. This result reflects our growth accounting finding that skills effects were only clearly present in these countries

We included seven systemic banking crises in the initial sample and in our final results only three had a significant long run negative impact; and these were Finland in 1991 (at 90 per cent significance level), Japan in 1997 (95 per cent sign level) and

the US in 1988 (at 90 per cent significance level). Out of the four remaining systemic banking crises, three (Spain 1977, Japan 1991, Sweden 1991) were found insignificant at the first stage and hence were unnecessary in the minimum cointegrating set. The crisis in the UK in 1974 was included in the initial long-run equation with a negative and significant parameter, but in the dynamic equation there was no explanatory power left for it once the effect from all other variables was taken into account. This may reflect its timing, as it occurred at the same time as a significant increase in oil prices, which had an effect on sustainable output in the UK and elsewhere. The oil price effect on productivity is one of the common factors covered by the CCE variables, and hence once we put the UK into the panel the independent impact of the crisis disappears<sup>13</sup>. The initial effect in the cointegrating vector can therefore be seen as spurious.

In Table 6 we analyse the effects that factors behind technical progress played in the growth rate of productivity in each country. We break down the change in productivity into the contribution from the components in table 5 over 10 year intervals from 1977 to 2007<sup>14</sup> so that it is comparable to Table 1 above. We can partition the factors driving productivity loosely into three groups, knowledge, competition and skills.

The first factor involves the creation and absorption of knowledge through R&D and FDI. There is a core group of knowledge creators identified in our analysis, which along with the US produce information, and it is at least in part disseminated through the port of FDI This factor is present in all countries, but it is lower in the UK in the first period than in all countries other than Canada and only Germany is lower in the second period. Over the period 1997 to 2007 there was a minor improvement in the UK's relative and absolute performance driven by these knowledge factors, with Belgium, Spain and Germany having a lower contribution.

The second factor based on competitive market pressure effects from openness and regional integration is more important as a driver of labour productivity in the UK than in other countries in all time periods except for Spain around the time it joined the EU and Germany around the time of unification. Overall the UK benefits more in the last two periods from the market efficiency indicators than it in the first period, suggesting that product market reforms began to impact on the UK

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<sup>13</sup> In particular we should stress that for the UK there is no evidence that any banking crisis since the second war has had a significant and negative impact on productivity per person hour.

<sup>14</sup> We take geometric mean of annual changes both in the dependant and independent variables.

**Table 6: Contribution to the change in productivity**  
*percentage point contribution to average annual growth in productivity*

		Belgium	Canada	Denmark	Finland	France	Germany	Japan	Neths	Sweden	Spain	UK	US
Output per person hour	1978-1987	2.2	1.0	1.0	3.0	3.1	2.1	3.0	2.1	1.1	3.3	2.4	1.6
	1988-1997	2.3	1.3	2.5	3.0	2.3	2.8	3.0	1.5	2.1	1.8	1.9	1.6
	1998-2007	1.0	1.3	1.0	2.5	1.9	1.7	1.7	1.4	2.2	0.0	2.2	2.0
<i>of which</i>													
Foreign direct investment (as a % of GDP)	1978-1987	0.9	0.3	-	-	0.3	-	-	0.9	0.7	1.1	0.5	1.0
	1988-1997	0.1	0.1	-	-	0.9	-	-	0.4	0.8	0.2	0.1	0.4
	1998-2007	0.1	0.6	-	-	0.9	-	-	0.8	1.0	0.3	0.6	0.6
Research & development (as a % f GDP)	1978-1987	-	-	0.9	2.4	0.9	1.0	1.6	-	-	-	-	-
	1988-1997	-	-	0.9	2.3	0.5	0.0	1.2	-	-	-	-	-
	1998-2007	-	-	0.9	1.7	-0.2	0.3	0.9	-	-	-	-	-
Openness	1978-1987	-	0.2	-	0.1	-	0.3	-	-	0.4	-	0.6	-
	1988-1997	-	0.8	-	0.4	-	0.5	-	-	0.8	-	1.4	-
	1998-2007	-	0.1	-	0.3	-	0.8	-	-	0.7	-	1.0	-
European single market	1978-1987	0.0	-	0.0	-	-	0.1	-	0.0	-	-	-	-
	1988-1997	1.1	-	1.1	-	-	1.2	-	0.6	-	-	-	-
	1998-2007	0.0	-	0.0	-	-	0.0	-	0.0	-	-	-	-
European union (1986)	1978-1987	-	-	-	-	-	-	-	-	-	1.1	-	-
	1988-1997	-	-	-	-	-	-	-	-	-	0.0	-	-
	1998-2007	-	-	-	-	-	-	-	-	-	0.0	-	-
Skills accumulation	1978-1987	-	-	-	-	-	-	-	-	-	-	0.4	0.5
	1988-1997	-	-	-	-	-	-	-	-	-	-	0.4	1.0
	1998-2007	-	-	-	-	-	-	-	-	-	-	0.0	1.2

Skills accumulation contributes to productivity growth only in the US and the UK, albeit for different reasons<sup>15</sup>. The decomposition analysis suggests that the effect on productivity from skills accumulation has been stronger in the US as compared to the UK. And also, while in the US skills were playing an increasing role in productivity growth, in the UK their contribution remained broadly unchanged over the first 20 years of the sample and reduced to 0 in the last ten years.

### **Recent Performance**

Some of the improved UK performance seen in the last decade we study may have been lost in the recent financial crisis. If financial liberalisation contributed to productivity growth outside the financial sector as well as in it, the crisis could have effects throughout the economy. Some of the gains in productivity were clearly illusory, but we have argued that these will have contributed no more than 0.2 to UK productivity growth over the period as compared to an average of 0.1 in our sample. However, if the crisis has led to deeper recession or a larger scar in the UK growth could be weaker in the coming decade.

The financial market crisis that started in the summer of 2007 and worsened in the autumn of 2008 has led to a sharp short term decline in output that exceeds its longer term impact. We estimate that the permanent scar on output per person hour might be around three percent. The scar is largely driven by a presumed 300 basis point rise in risk premia along with a structural deterioration in the budget balance which is no worse in the UK than in the average of other countries. The risk premium effect is, as far as we can see, likely to be common. The size of the scar differs between countries, and as Barrell (2009) discusses it will depend upon the relative size the capital stock as compared to GDP, and the UK has a relatively low capital output ratio and a relatively high user cost and hence the rise in the risk premium will have more effect in countries such as Germany, as is suggested in Barrell (2009).

There are of course other factors to take into account for the impact of the scar to output (not productivity) and Barrell, Gottschalk, Kirby and Orazgani (2009) suggest that there could be up to one percent more reduction in output as a result of increased out migration. This is in part because the major migrant source countries in recent years have included Poland and Australia, the only OECD countries not to face a recession in 2008 and 2009, and the Indian subcontinent where performance has remained strong. Hence migrants from these countries will find the UK less attractive

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<sup>15</sup> In the US both the number of graduates and their skill premium has risen, whilst in the UK the number of graduates rises continually but the skill premium begins to decline just before 2000

both in the short and long run. In addition s the European economy revives barriers to Polish migration to the rest of Europe will have been removed.

## **Conclusion**

Economic performance in the UK clearly improved between 1997 and 2007 as compared to other countries in the OECD. Only a small part of this can be attributed to the growth of financial services, as this sector expanded in other countries as well. The contribution of skills to the improved performance was not as large as might have been expected because the skill premium declined in the face of large increase in skilled workers. The major improvements appear to have come through increases in the efficiency with which factors are used, and these improvements can be associated with policies such as the Competition Act of 200 which have focused more clearly on competition and efficient regulation than had the earlier reforms and privatisations. Although UK institutions do not appear to be robust to the downturn, and performance has not been good there are reasons to believe the scar from the crisis on output per person hour (but perhaps not output) will be around the average for the group of countries we consider.

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## Appendix. Data description and sources

CRIS – Introduced to capture the long run impact of banking crises and modelled as 0 prior to the crisis occurrence and 1 thereafter. Only systemic crises are included (Finland 1991; Japan 1991, 1997; Spain 1977; Sweden 1991 and the US 1988). Data source IMF Financial Crisis Episodes database and World Bank database of banking crises.

E – Total employment (thousands). Data source NiGEM database.

EMU – Is introduced to capture the impact of the European Monetary Union, which equals to 1 from 1999, in line with the official introduction of single currency in Europe and is zero prior to 1999.

ESM – Describes the establishment of the European Single Market, which is defined as zero prior to 1987 and then gradually increases to one in 1992, the formal completion of the Single Market Programme.

EU86 and EU95 – Are meant to take an account of the impact on country upon joining the European Union (EU) and modelled to be zero before the country joins the EU and one thereafter.

FDI – Stock of foreign direct investment in the country (in constant prices and national currencies). Source UNCTAD, <http://unstats.un.org>.

H – Hours worked per employee per quarter. Data source NiGEM database.

OPEN – Is a measure of the openness of the economy and defined as a share of volumes of exports and imports of goods and services in GDP. Data source NiGEM database.

R&D – Stock of Research and Development. We benchmark the stock in 1973, in the first year of our data period, as flow divided by the average growth rate and the depreciation rate, and we cumulate flows onto this stock with a depreciation rate of 15 per cent per annum. The data source is OECD Main Science and Technology Indicators 2009-2 (1981-2008) and Research and Development Expenditure in Industry database, 1973-1998, <http://www.sourceoecd.org>.

SKILLS – Tornqvist based measure of workforce skills. It is a compound skill indicator which uses indicators of relative compensation for each of three (high, medium and low) skill groups to construct index of efficiency units of labour for each country, with a higher value of the index implying a higher level of knowledge embodied in workers. Data comes from EUKLEMS database, <http://www.euklems.net/>.

Y – GDP in basic prices. Data source NiGEM database, except US and Japan where they are NIESR estimates using indirect taxes and subsidies and the GDP deflator..