Accounting for UK economic performance 1973-2007

Ray Barrell[1], Dawn Holland[2] and Iana Liadze[34]

Abstract: Economic performance in the UK improved between 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 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.

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[1] Brunel University; ray.barrell@brunel.ac.uk
[2] NIESR
[3] NIESR
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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. We may use growth accounting, or we can estimate a cross-country panel regression. We have combined these approaches previously in Barrell, et al (2007) and in Barrell, et al (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.

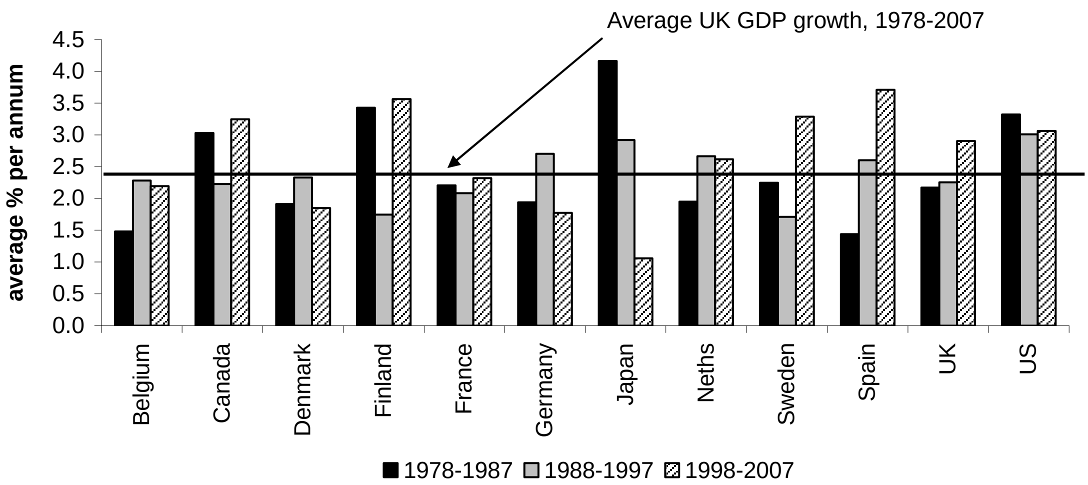
Growth accounting on basic price income data is performed for labour hours, labour quality and capital inputs, and hence a true Total Factor Productivity (TFP) residual is calculated. This allows us to decompose growth into a component driven by capital deepening, one by raw labour input, and another 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.

We start with 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 some 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 advanced economies.

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.

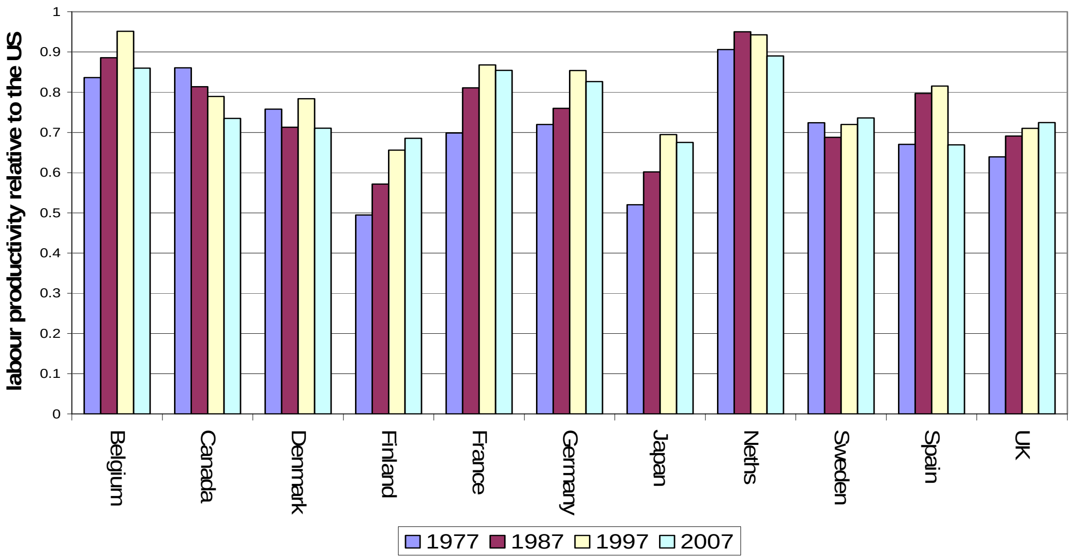
Figure 1. UK GDP growth (basic prices) in perspective



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 in most of the other countries studied here, and higher only than in Finland and in Japan[5]. 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 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=1.0, 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

[5] 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.

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 illusionary, 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 polices 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[6].

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[7].

We adopt a Tornqvist discrete time version of a Divisia index to construct an indicator of workforce skills. The EUKLEMS[8] 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 time was calculated.[9] 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[10] is then calculated as:

$$Ln(TQ) = \sum_{J=1}^{3} S_{jt} (\ln x_{jt} - \ln x_{j,t-1}) \qquad \text{with } S_{jt} = 0.5(S_{jt} + S_{jt-1}) \tag{1}$$

[6] 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.

[7] 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

[8] 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.

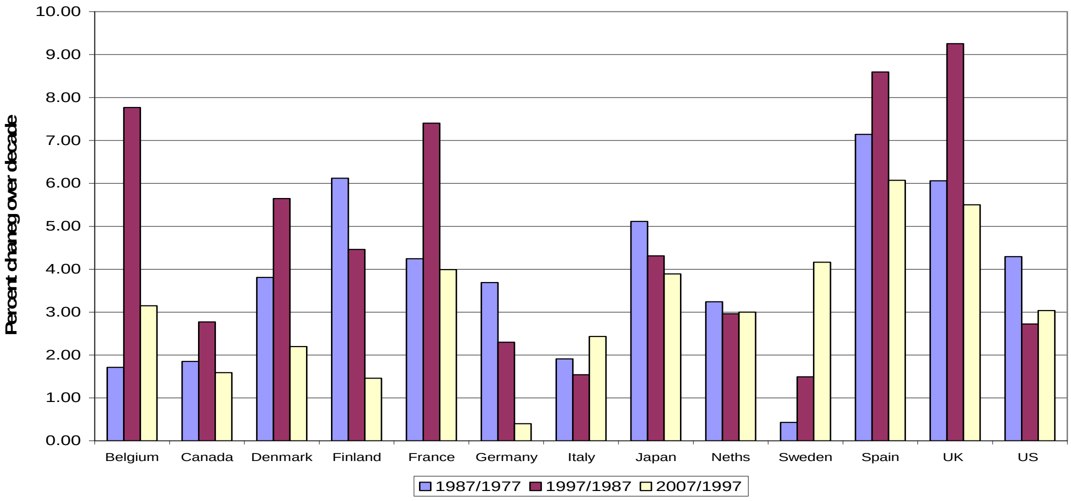
[9] The relative wage is the share of total compensation received by a skill category divided by the share of total hours contributed by the same group.

[10] This is a weighted sum of the growth rates of the various components, where the weights are the component's shares in total value.

where TQ is the Tornqvist index, S_{jt} is the share of the wage bill directed to skill category j at time t and x_{jt} is the share of hours worked by the skill 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[11]. 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. [12]

There are common trends across all countries in both compensation shares and hours worked by less skilled workers, with an increasing share of hours worked and compensation received by high skill employees. However, the relative speed and size of the change in shares lead to different time patterns of skill indices in the countries. The Tornqvist skill index increases over time in all countries, with the largest increases in the UK and the US, followed by Spain, as we can see from Figure 3. Skills have risen least rapidly in Germany, Canada and Sweden. In all 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. This has a positive effect on our indicator of skills which is based on the assumption that higher wages indicate higher productivity.

Figure 3 Growth in Skills



NIESR calculations based on EUKLEMS

[11] 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.
[12] Where data is absent we assume constant shares of skill categories.

Regression analysis

In this section we analyse in 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/(E*Hours) where Y is output in basic prices, E is employment and Hours are average 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 (2) 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:

$$Ln(y) = F(k, S, t, x) \qquad (2)$$

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 a three year period) to capture the gradual process of integration of a country into membership 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

$$\begin{aligned} ln(y_t) = d_1 + d_3{*}ln(k)_t + d_4{*}ln(FDI/Y)_t + d_5{*}ln(R\&D/Y)_t + \\ d_6{*}ESM_t + d_7{*}ln(OPEN)_t + d_8{*}ln(S)_t + \\ d_9{*}EU86_t + d_{10}{*}EU95_t + error_t \end{aligned} \qquad (3)$$

We substitute out k and replace it with its determinants which we take to be the user cost of capital and banking 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

$$ln(y_t) = d_0 + d_3 {*} ln(user)_t + d_4 {*} ln(FDI/Y)_t + d_5 {*} ln(R\&D/Y)_t + d_6 {*} ESM_t + d_7 {*} ln(OPEN)_t + d_8 {*} ln(S)_t + d_9 {*} EU86_t + d_{10} {*} EU95_t + d_{11} {*} CRIS_t + error_t \quad (4)$$

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[13] 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 1 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 1: 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	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

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 2 show that all equations for all countries in the sample cointegrate, implying we have an acceptable specification. In no country is the user cost of capital a significant variable in the cointegrating set.

Table 2: 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*

[13] There are several cases when variables are difference stationary without an inclusion of an intercept.

We then use the minimum cointegrating set in the context of a simple error correction framework as in (4).

$$Dln(y_t)_t = d_1 + d_2*((ln(y)_{t-1} + d_3*ln(user)_{t-1} + d_4*ln(FDI/Y)_{t-1} + d_5*(R\&D/Y)_{t-1} + d_6*ESM_{t-1} + d_7*ln(OPEN)_{t-1} + d_8*ln(S)_{t-1} + d_9*EU86_{t-1} + d_{10}*EU95_{t-1} + d_{11}*CRIS_{t-1}) + d_{12}*Dln(y_{t-1}) + error_t \quad (4)$$

Productivity in country i does not evolve in isolation, but is also dependent on productivity developments in the rest of the world. In order to account for the common global drivers of productivity that are not explicitly included in the estimated model, we use the Common Correlated Effects (CCE) (Pesaran, 2006) method for estimation. Ordinary Least Squares (OLS) is applied to the system of error correction equations, with cross-section 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.

Table 3. Unrestricted model estimates

	Belgium	Canada	Denmark	Finland	France	Germany	Neths	Sweden	Spain	UK	US
Error correction	**-0.267**	**-0.441**	**-0.671**	**-0.545**	**-0.376**	**-0.265**	**-0.528**	**-0.453**	**-0.378**	**-0.671**	**-0.254**
Ln(R&D/Y)	0.004	-0.002	0.138	**0.421**	**0.949**	0.350	0.161	-0.175	**0.279**	**0.447**	0.193
Ln(Open)	-0.295	0.080	-0.187	-0.033	**0.675**	0.107	-0.132	0.066	-0.064	0.333	0.159
Ln(FDI/Y)	**0.020**	0.052	0.011	0.001	-0.005	-0.010	**0.075**	0.069	0.010	0.002	0.028
Ln(SKILLS)	0.888	-0.335	0.316	-0.490	-2.129	0.344	0.822	1.116	**-2.176**	**1.314**	0.424
AvLn(Y/EH)	**0.386**	**0.386**	**0.386**	**0.386**	**0.386**	**0.386**	**0.386**	**0.386**	**0.386**	**0.386**	**0.386**
AvDLn(Y/EH)	**1.355**	**1.355**	**1.355**	**1.355**	**1.355**	**1.355**	**1.355**	**1.355**	**1.355**	**1.355**	**1.355**
ave open	***0.110***	***0.110***	***0.110***	***0.110***	***0.110***	***0.110***	**0.110**	***0.110***	***0.110***	***0.110***	***0.110***

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; AvLn(y) - unweighted cross-section average of the natural log of output per person hour; AvDLn(y) - unweighted cross-section average of the difference of the natural log of output per person hour; ave open – unweighted cross-section average of ln(Open); estimation period 1974-2008. The CCE terms were estimated within the long-run of the equation for ease of interpretation. Additional dummy variables and dynamics were included in estimation, but are not reported here. Bold indicates significance at the 5% level. Bold italics indicates significance at the 10% level.

Table 3 reports results of an unrestricted model, which includes all of the significant CCE terms. We impose a common coefficient across countries on the CCE terms, which allows us to separately identify the effects of the global rate of innovation and productivity, which can be viewed as weakly exogenous to the individual economies, and domestic drivers of innovation and absorption, which endogenously determine productivity developments within an economy. The global rate of innovation and the rate of globalisation have both been key factors driving productivity developments in all the major economies.[14]

The estimates reported in table 3 suggest that productivity growth is partly exogenous to the individual economy, and on average individual economies have absorbed about 40 per cent of the rise in global productivity driven by common unobserved factors. Globalisation has also played an important role, with a 1 per cent rise in the average rate of openness association with a 0.1 per cent rise in average productivity. The estimates also support the presence of an endogenous growth process, with factors such as the intensity of R&D, inflows of FDI, the accumulation of workforce skills and openness of the economy allowing some countries to grow more rapidly than others.

In order to develop a more parsimonious model, in the next stage of the estimation a 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 4.

[14] We do not include Japan in this analysis as it may not share the common trends

Table 4: Estimation results

	Belgium	Canada	Denmark	Finland	France	Germany	Japan	Neths	Sweden	Spain	UK	US
Error correction	-0.19 (0)	-0.248 (0.01)	-0.538 (0)	-0.568 (0)	-0.16 (0.004)	-0.213 (0.012)	-0.183 (0.001)	-0.256 (0.003)	-0.378 (0)	-0.205 (0)	-0.375 (0)	-0.255 (0.015)
Ln(FDI/Y)	0.013 (0.045)	0.126 (0.017)	-	-	0.096 (0.033)	-	-	0.081 (0.011)	0.074 (0.01)	0.032 (0)	0.048 (0.001)	-
Ln(R&D/Y)	-	-	0.255 (0)	0.468 (0)	0.425 (0.056)	0.33 (0.04)	-	-	-	-	-	-
Ln(Open)	-	0.182 (0.008)	-	0.099 (0.003)	-	0.159 (0.056)	-	-	0.246 (0.054)	-	-	0.297 (0.001)
European single market	0.123 (0.004)	-	0.112 (0)	-	-	0.132 (0.001)	-	0.068 (0.032)	-	-	-	-
EU membership 1986	-	-	-	-	-	-	-	-	-	0.115 (0.008)	-	-
Ln(SKILLS)	-	-	-	-	-	-	4.7 (0)	-	-	-	2.066 (0)	1.848 (0.019)
Long run crisis effect	-	-	-	-0.029 (0.048)	-	-	-0.143 (0)	-	-	-	-	-0.061 (0.054)
Crisis date				1991			1997					1988
DLn(Y/EH(-1))	-	-	-	0.413 (0.001)	-	-	-	-	0.458 (0.001)	0.435 (0.001)	0.288 (0.062)	-
AvLn(Y/EH)	0.078 (0)	0.078 (0)	0.078 (0)	0.078 (0)	0.078 (0)	0.078 (0)	0.078 (0)	0.078 (0)	0.078 (0)	0.078 (0)	0.078 (0)	0.078 (0)
AvDLn(Y/EH)	0.737 (0)	0.737 (0)	0.737 (0)	0.737 (0)	0.737 (0)	0.737 (0)	0.737 (0)	0.737 (0)	0.737 (0)	0.737 (0)	0.737 (0)	0.737 (0)

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(S) - 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 significantly different from each other.

The different nature of technical progress and market competition across different countries is illustrated by each country except the two largest, the US and Japan, 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 7 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 marginally significant in France, where its significance may be clouded by the presence of an FDI effect, as France is the only country where both have an independent role. In all cases, R&D has a positive sign, indicating that higher R&D enables these countries introduce technical advancements more readily. The magnitude of the effect of R&D varies, with Finland showing the highest significant effect and Denmark the lowest. The US and Japan undertake a lot of R&D, but this appears to be absorbed in the common trend.

Efficiency indicators are present in all countries expect 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 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 (at 95 per cent significance 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[15]. The initial effect in the cointegrating vector can therefore be seen as spurious.

In Table 5 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 4 over 10 year intervals from 1977 to 2007[16] so that we can compare the immediate pre crisis period with the slow early one and the start of the great moderation, at least in the US.

The first group 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 and Japan produce information, and it is at least in part disseminated through the port of FDI. This factor is present in all countries except the US and Japan, but it is lower in the UK in the first period than in all countries with the exception of 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 external market pressure effects from openness and regional integration is more important as a driver of labour productivity in Germany than in other countries, except in Spain around the time it joined the EU. The remaining component of overall productivity growth might be seen as domestic market pressure, and this is stronger in the UK in the last period than in all countries except France and Belgium.

Skills accumulation contributes to productivity growth only in the UK, Japan and the US, albeit for different reasons[17]. The decomposition analysis shows that the impact of the accumulation of skills has been more rapid in the UK and Japan relative to the US, and while in the US skills were playing an increasing role in productivity growth, in the UK their contribution peaked in the middle decade, although it continued to contribute to productivity growth strongly in the last ten years of our sample period.

[15] 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.
[16] We take geometric mean of annual changes both in the dependant and independent variables.
[17] 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.

Table 5: 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
Knowledge	*of which*													
	Foreign direct investment (as a % of GDP)	1978-1987	1.0	0.3	-	-	0.3	-	-	1.0	0.8	1.1	0.4	-
		1988-1997	0.1	0.1	-	-	0.9	-	-	0.4	0.8	0.2	0.1	-
		1998-2007	0.1	0.6	-	-	0.9	-	-	0.9	1.0	0.3	0.4	-
	Research & development (as a % f GDP)	1978-1987	-	-	0.9	2.5	0.9	1.0	-	-	-	-	-	-
		1988-1997	-	-	0.9	2.3	0.6	0.0	-	-	-	-	-	-
		1998-2007	-	-	0.9	1.7	-0.2	0.3	-	-	-	-	-	-
Competition	Openness	1978-1987	-	0.2	-	0.1	-	0.3	-	-	0.4	-		0.7
		1988-1997	-	0.8	-	0.4	-	0.6	-	-	0.8	-		1.4
		1998-2007	-	0.1	-	0.3	-	0.8	-	-	0.7	-		0.7
	European single market	1978-1987	0.0	-	0.0	-	-	0.1	-	0.0	-	-	-	-
		1988-1997	1.2	-	1.1	-	-	1.3	-	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	Skills accumulation	1978-1987	-	-	-	-	-	-	2.3	-	-	-	1.2	0.8
		1988-1997	-	-	-	-	-	-	2.0	-	-	-	1.8	0.5
		1998-2007	-	-	-	-	-	-	1.8	-	-	-	1.1	0.6
	Domestic market pressure (a residual)													
		1978-1987	1.2	0.5	0.1	0.4	1.9	0.7	0.7	1.1	-0.1	1.1	0.8	0.1
		1988-1997	1	0.4	0.5	0.3	0.8	0.9	1	0.5	0.5	1.6	0	-0.3
		1998-2007	0.9	0.6	0.1	0.5	1.2	0.6	-0.1	0.5	0.5	-0.3	0.7	0.7

Growth accounting

Solow's (1957) 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)[18]. This approach assumes a general underlying production function that maps the factor inputs to final output, thereby representing the productive capacity of an economy. This can be expressed as:

$$Y = f\left(K_t, L_t, T_t\right) \tag{5}$$

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.

$$d\ln(Y_t) = \theta_{K_t} d\ln(K_t) + \theta_{L_t} d\ln(L_t) + dA_t \tag{6}$$

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

$$dA_t = \frac{f_{T_t} T_t}{Y_t} d\ln(T_t) \tag{7}$$

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

$$L = E * Hours * S \tag{8}$$

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:

$$d\ln(Y_t) = \theta_{K_t} d\ln(K_t) + (1-\theta_{K_t}) d\ln(E_t * Hours_t) + (1-\theta_{K_t}) d\ln(S_t) + dA_t \tag{9}$$

A common growth accounting practice is to subtract the growth rate of (unadjusted) labour input from both sides of equation (9), to derive a decomposition of labour productivity into its components:

$$d\ln\left(\frac{Y_t}{E_t * Hours_t}\right) = \theta_{K_t} d\ln\left(\frac{K_t}{E_t * Hours_t}\right) + (1-\theta_{K_t}) d\ln(S_t) + dA_t \tag{10}$$

[18] Other terms for the indicator are Solow residual, measure of ignorance, or rate of technical change.

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 6 we use the simple relationship between output, labour input and labour productivity:[19]

$$Y = (E * Hours) * \frac{Y}{(E * Hours)} \qquad (11)$$

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.

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 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.

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.

[19] Details of sources are included in an appendix

Table 5. Growth Decomposition

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)	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
of which													
Hourly labour input (unadjusted)	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
Output per person hour	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
of which													
Skills accumulation	1978-1987	0.1	0.1	0.3	0.4	0.3	0.2	0.4	0.2	0.0	0.4	0.4	0.3
	1988-1997	0.5	0.2	0.4	0.3	0.4	0.1	0.3	0.2	0.1	0.5	0.6	0.2
	1998-2007	0.2	0.1	0.1	0.1	0.2	0.0	0.2	0.2	0.2	0.3	0.3	0.2
TFP (excluding skills)	1978-1987	1.2	0.4	0.4	1.8	1.4	1.0	1.6	1.1	0.7	1.3	1.4	1.0
	1988-1997	0.9	0.5	1.8	1.9	0.7	1.7	1.2	1.0	1.1	0.1	0.8	1.1
	1998-2007	0.5	0.8	0.8	2.2	0.9	1.1	1.0	0.9	1.8	-0.6	1.2	1.2
Capital deepening	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

We can decompose the remaining component into skills and underlying labour productivity growth. Over the whole period the impact of skills has been largest in the UK, Spain, Japan and France. Residual productivity growth over the whole period has been particularly rapid in Finland, and has also been high in Japan, Germany and Sweden. In the most recent decade, TFP, after accounting for skills, has increased at an average rate of 1.2 per cent per annum in the UK, which has been 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.

The rise in productivity growth in the last decade may be the result of the process of attempting to improve the efficiency of factor use in the UK over our time period. The first was the start of the privatisation programme in 1984, which was based on a belief that private sector ownership was sufficient to ensure that productivity would improve because the threat of takeover, or an actual takeover, would improve productivity, 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 was 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.

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.

Table 6.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)	2.2	3.25	1.85	3.56	2.1	1.77	0.8	2.62	3.2	3.71	2.9	3.06
of which												
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	3.95	3.92	6.43	1.16	3.69	0.1	1.46	3.7	4.06	9.46	6.13	5.17
of which												
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 growth	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 rest of economy	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 sectorcontribution 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 contribution of the financial services sector to productivity growth is analysed further in table 6 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 sector's productivity growth as compared to the rest of the economy multiplied by the size of the sector. In the UK 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 (3.47*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 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. The period between 1997 and 2007 was unusual, in that the most productive country in our group in terms of output per person hour, the USA, actually began to pull further ahead of other countries, excepting the UK, Sweden and Finland. Although convergence of productivity levels has not been uniform there is a slow tendency for it to happen as Lee, Pesaran and Smith (1997) show. The decade to 2007 was an exception to this pattern whereas the previous decade had clearly confirmed it, with the USA having the third lowest level of labour productivity growth in Table 1. The literature on this topic is extensive, but there is an emerging consensus that the nature of the information and communications technology and bio-technology revolution was particularly suited to the US economy. The reasons for that reflect also on the performance of the UK, Sweden and Finland during the decade.

Over the last two centuries it is possible to describe the growth process as a sequence of product innovation cycles where new products such as the electric motor, the internal combustion engine or the computer are developed, followed by process innovation cycles where those products are improved (see Freeman and Soete (1997) for a discussion). Product innovation has often best been done in flexible labour markets with high levels of scientific skills. It depends upon a sound knowledge base and on entrepreneurial activity. Process innovation has often best been done in labour markets that have long attachments between firms and individuals where on the job training and firm specific skills are perhaps more important than high levels of scientific knowledge. The archetypes of these are the flexible US labour market where 25 per cent of the workforce change jobs each year (see OECD (2010) chapter 3 where adjustments are made for industrial composition of the workforce) as compared to the core Europeans, where only one sixth of Germans, for instance, change jobs each year. In 1997 only 8 per cent of the German workforce were high skilled whereas 28 per cent of the US workforce were in this category[20]. The period from the mid 1970s to the early 1990s was a period of process innovation where German (and other continental) firms improved ways of doing (see Prais (1995) for a discussion). During this period hourly productivity growth in the US was noticeably below that in Germany and France, as we can see from Table 1.

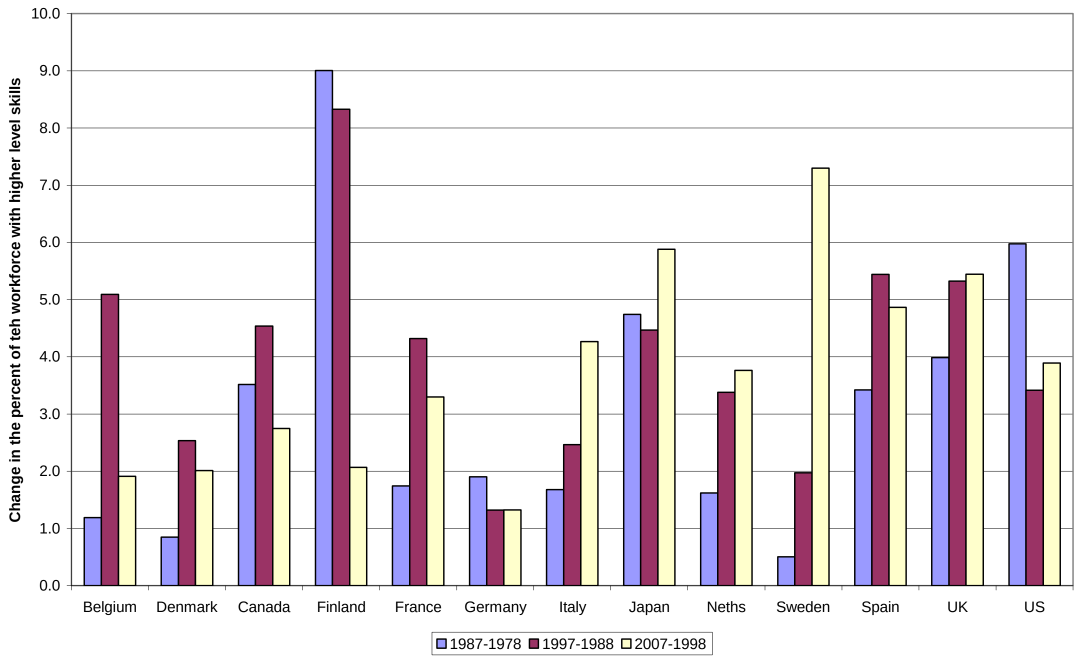
The last decade we look at was a period of innovation in bio-technology and information and communications technology, as well as in finance. This is just the period where we would expect the US to pull ahead, much as it did. These industries have involved university based research and have required small company start ups to initiate growth. The latter is best done in labour markets with low attachment rates such as the US. As we discuss above some of the improvement in performance in the US and elsewhere may have been illusory, in that some of the innovations in finance transferred rents rather than increased output, but much of the improvement elsewhere were real.

The performance and structure of the UK labour market is closer to that of the USA than to the core Europeans in many ways. Job turnover is only 2 per cent lower than in the US and is 5 per cent higher than in Germany. Skills are increasingly obtained through off the job education in the UK, with 13.5 per cent of the workforce with higher level skills in 1997, noticeably higher than in Germany but below that in the US. These factors may be part of the explanation of the improvement in productivity performance in the UK in the last decade in our study. The growth of higher education related skills in the UK in the last two decades, as measured by the increase proportion of the workforce with those skills, exceeded that of all other countries in our sample, as we can see from Figure 4. Finland, Japan, Sweden and Spain came close to the rate of increase in high skilled workers seen in the UK. The first three are the amongst the best performers in the last decade, with productivity per person hour both before and after allowing for capital deepening growing most rapidly in Finland

[20] We use EUKLEMS definitions of skills in order to be consistent with our growth accounting work These individuals have the equivalent of a degree. OECD (2010a) suggests that the disparity for tertiary education was less, with 23 per cent of Germans and 34 per cent of US workers have a qualification at this level.

and Sweden. The impact of the growth of labour with high skills in Spain is masked by the scale of immigration into the economy in that decade. High skilled immigrants tend to take lower level jobs than their skills would suggest, and often their skills, which were obtained in another country, may not be transferrable. It is clear that the countries with the highest levels of high skilled workers, the US with 28 per cent in 1997, Finland (with 33 per cent) and Japan (20 per cent) were able to benefit from these skills during a period of product innovation. The level of high skills in Sweden is relatively lower than in Finland (although recent growth has been strong, as we can see from Figure 4), although the rate and nature of productivity growth in both has been similar, with a very strong science base. This leads us to a distinction between quality and quantity to which we turn next.

Figure 4 The growth of high level skills

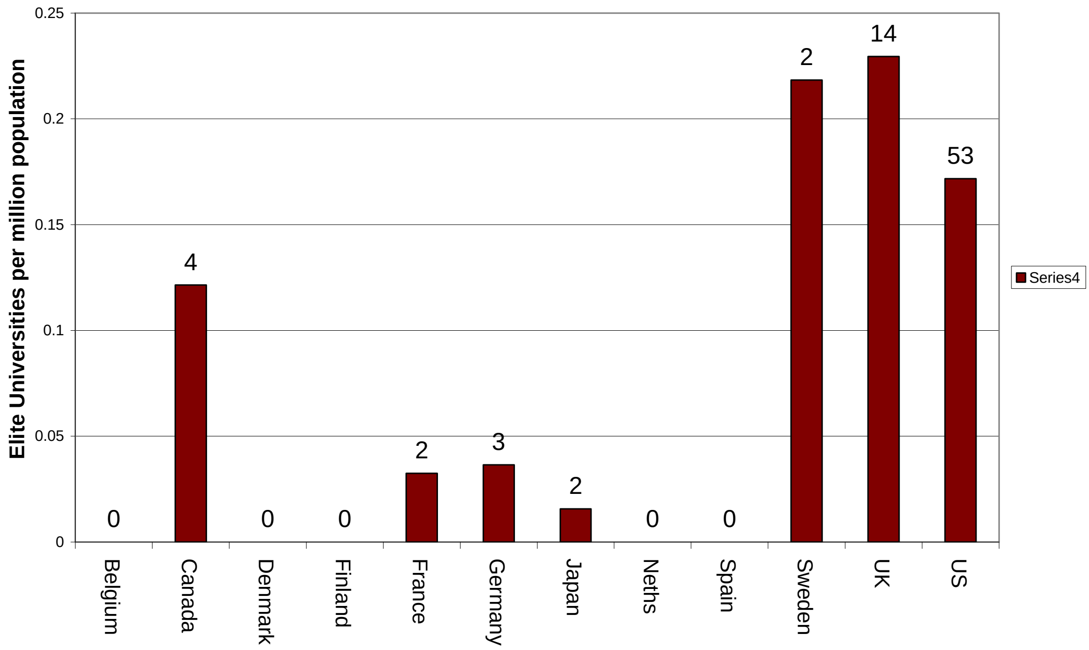


Source EUKLEMS

There are other dimensions to the bio-technology, information and communications technology revolution that make it different from some previous product innovation waves. Both the products in bio-technology and the processes in computer development are more closely linked to university level research and innovation than were the development of the internal combustion engine or the construction of an electrical equipment based economy.

Universities, like individuals, come in many guises, some are centres for elite education others for frontier research, whilst the majority may be neither of these. There are also many ways of grading universities in terms of their teaching or their research.[21]. Our group of countries contains 80 of the 100 best universities in the world, with the remaining 20 being in Australia (5), Switzerland (4), China and Hong Kong (3 and 2), Ireland (2), Korea (2), Norway and Singapore. Figure 5 plots the number of elite universities in each country in our sample both in terms of absolute numbers and per million of population. The US, the largest country here, has 53 elite universities, whilst the UK has 14[22]. These countries have the highest number per million of population along with Sweden which has 2 elite institutions. Hence the combination of indicators of the volume of higher education in the workforce and the quality of the output of universities appear to be important structural factors in explaining why the UK, the US, Sweden and Finland have moved ahead of others in the last decade.

Figure 5 Distribution of the top 100 universities in the world



Data Times Higher Education Supplement and NIESR database

Clearly elite universities may be one factor behind the pattern of productivity growth in our sample in the last decade. The number of such institutes per million of population has a correlation of 0.37 with productivity performance in the last decade, both as measured by overall TFP growth and by TFP growth less the contribution of skills. The UK, along with Finland and the US have benefitted from their relatively high number of high skilled workers, whilst the UK, the US and Sweden have benefited by being important centres for scientific research.

[21] We use the 2010 version of the Times Higher Education Supplement world university rankings which uses a combination of research, citations and teaching to rank the top 100 universities in the world See www.timeshighereducation.co.uk/world-university-rankings

[22] There is an English language bias in the evaluation of elite universities, as the core language of science is English, and for instance if universities in France have policies to promote French language journals then their ranking will be affected. This bias does affect our overall conclusion.

Product innovation cycles are often followed by periods of process innovation when leadership changes hands, and we might expect this to happen again. It is of course impossible to know where the next wave of scientific innovation might come from, but it would be reasonable to suppose that over the next two decades we will see another period of product innovation to deal with the causes and consequences of climate change. De-carbonising the economy is likely to be a knowledge intensive activity based on the frontiers of science, and hence countries such as the UK, the US and Sweden may be in a good position to pull further ahead. Of course this depends upon the continued existence of scientifically excellent universities and research institutions as well as other factors affecting productivity growth. We next consider an approach that will allow us to look at the factors that have affected this improvement in underlying TFP.

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 quite large, as might have been expected given the increase in the proportion of the workforce with higher education, although the skill premium declined in the face of large increases in skilled workers. Major improvements appear to have also come through increases in the efficiency with which factors are used, and these improvements can be associated with policies toward domestic aspects of competition such as the Competition Act of 2000, which have focused more clearly on competition and efficient regulation than had the earlier reforms and privatisations. In addition, the quality of UK higher education institutions appears to have also contributed to good performance during a product innovation period based on bio-technology and computing. This strength may be particularly important going forward as the need to reduce carbon emissions will is likely to be addressed only with a major investment in research in the area. Although UK institutions do not appear to be robust to the downturn, and performance has not been good, there are reasons to believe that 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.

HOURS – 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 souse 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.

S – 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 subsides and the GDP deflator..