Europe's Productivity Gap: Catching Up or Getting Stuck?

by Bart van Ark[1]
Groningen Growth and Development Centre
University of Groningen
and
The Conference Board Europe

Paper presented at
International Symposium on Productivity, Competitiveness and Globalisation
Banque de France, Paris
4 November 2005

1. Introduction

During the second half of the 1990s the comparative growth performance of Europe vis-à-vis the United States has undergone a marked change. For the first time since World War II labour productivity growth in most countries that are now part of the European Union (EU) fell behind the U.S. for a considerable length of time. Until the beginning of the 1970s rapid labour productivity growth in the EU went together with a catching-up in terms of GDP *per capita* levels on the U.S.. A first break in this pattern occurred in the mid 1970s. While catching-up in terms of labour productivity continued, the gap in GDP *per capita* levels between the EU and the U.S. did not narrow any further after 1975 (see Figure 1). This differential performance reflects the slowdown in the growth of labour input in Europe, which was related to increased unemployment, a decline in the labour force participation rates and a fall in average working hours. The second break, which is the focus of this paper, occurred in the mid 1990s when the catching up in terms of labour productivity also came to a standstill once the average EU level reached the U.S.

[1] This paper is largely based on earlier work, including Van Ark (2005) , O'Mahony and Van Ark (2003), McGuckin and Van Ark (2005a), Timmer and Van Ark (2005) and Van Ark and Inklaar (2005).

level. In fact a new productivity gap opened up since 1995. Whereas average annual labour productivity growth in the US accelerated from 1.1% during the period 1987-1995 to 2.5% during 1995-2004, EU productivity growth declined from 2.1% to 1.4%.[2]

The urgency of the 'European' problem is underlined by the rapid improvements in economic performance of countries in Central and Eastern Europe and Asia. Average labour productivity in the new EU member states increased at 4.2% from 1995-2004. In China and India, GDP per person employed (i.e. not corrected for changes in working hours) was 3.9% and 6.1% respectively from 1995-2004.

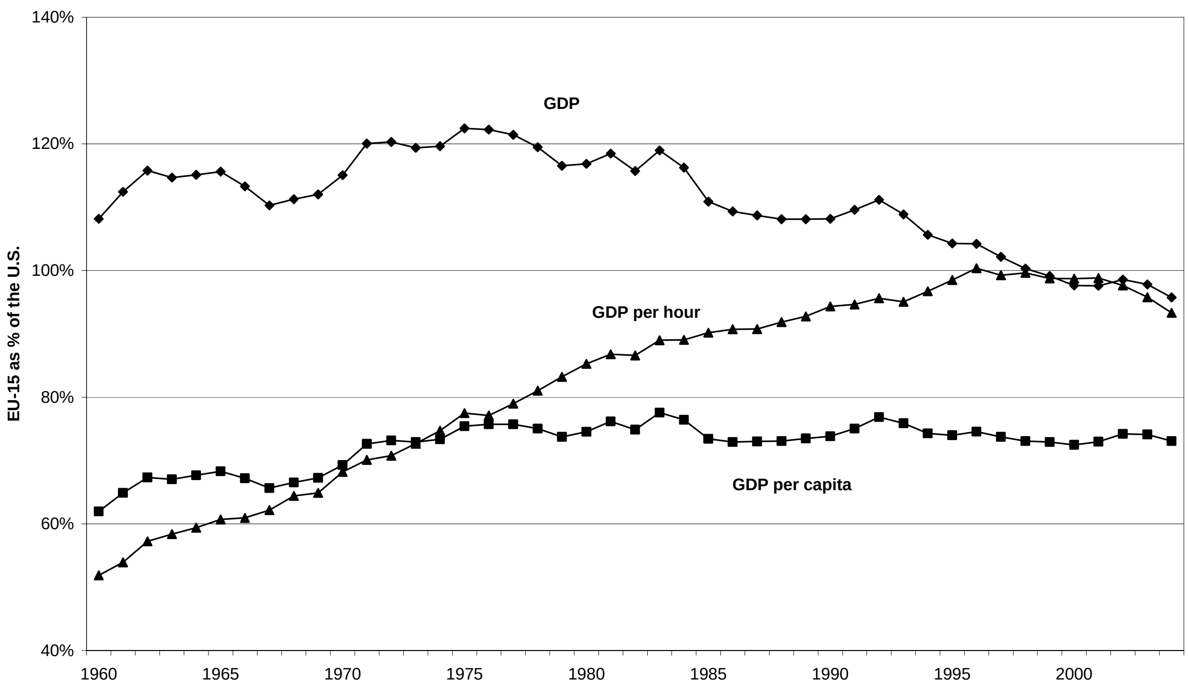
The striking acceleration in U.S. output and productivity growth in the mid 1990s has been much discussed in the literature. A consensus has emerged that faster growth can at least in part be traced to the effects of the information and communication technology (ICT) revolution (Oliner and Sichel 2000, 2002; Jorgenson and Stiroh 2000; Jorgenson, Ho and Stiroh, 2003), which in turn has depended on a surge in ICT investment, strong productivity effects from ICT-producing industries and a more productive use of ICT in the rest of the economy. In addition the U.S. economy has also benefited from a greater flexibility of markets in allocating resources to their most productive uses. This is partly realised through the labour market, as the substitution of low-skilled for high-skilled labour has proceeded more smoothly and the restructuring of the economy was not hindered. It has also been realised through product markets, in particular through the creation of new opportunities for productive applications of ICT mainly in service industries and service-related activities in manufacturing. Finally, the combination of reforms and adoption of new technologies has supported creativity of firms and entrepreneurs to develop new products and services and to reshape the organisational and production processes by which these are brought to the market.

Unfortunately there is much less consensus on the causes of the slowdown in Europe. Indeed the reasons for the limited impact of technology, innovation and structural

[2] Business cycles in the U.S. and the EU are not completely synchronised. However, the divergent trend growth rates are clear.

reforms on economic growth in Europe are still poorly understood. The urgency to better grasp the causes of the problems is underlined in the recent review by the Kok Commission of the Lisbon agenda for reform in Europe, which aims to improve Europe's competitiveness (European Commission, 2004). Indeed, the Kok report strongly argues for a revival of productivity growth in Europe, in particular in the light of demographic trends towards a smaller labour force relative to the total population in Europe.

Figure 1: GDP, GDP *per capita* and GDP per hour, 1955-2003



Note: EU refers to 15 EU membership as before 1 May 2004.
Source: Groningen Growth and Development Centre (GGDC) & The Conference Board (TCB).

At the same time, however, there is also considerable diversity in terms of both productivity growth as well as comparative levels between European countries. Comparative growth rates of labour productivity between 1995 and 2004 differ between – 0 per cent (for Spain) and 4.7 per cent (for Ireland). And there is a variation of plus 28 percentage points (for Belgium) and minus 49 per cent (for Portugal) in terms of each country's productivity level relative to the US in 2004. Hence although there are also some common traces to the European growth problem, one cannot simply treat the European area as homogeneous.

The cross-regional diversity in productivity performance cannot be fully understood without adopting an industry perspective to output, input and productivity performance. Thus there is a need to go beneath the aggregate numbers to ascertain to what extent variations across countries are largely explained by differences industry structure. In addition it needs to be considered whether these features are common to all or just a subset of EU countries.

This paper argues that the European slowdown in growth is a reflection of an adjustment process towards a new industrial structure, which has developed more slowly in the EU than in the U.S.. Rapid diffusion of new technology will facilitate the adjustment process in the future. However, an institutional environment that slows down change may hold up the structural adjustment process in Europe and inhibit the reallocation of resources to their most productive uses. The European economic environment creates too little room for good firms to excel and for failing firms to exit the market so as to free up resources for the much-needed transition.

This paper begins with a brief review of the aggregate estimates of productivity and per capita income in order to identify the extent to which labour market developments rather than productivity has impacted the comparative performance of the EU relative to other regions and countries (Section 2). I then proceed to examine the comparative productivity performance of the EU and the U.S. from the perspective of the contributions of the main growth drivers, which are ICT and 'other' capital deepening and total factor productivity (TFP). (Section 3). Next I approach the differential labour productivity growth performance from a sectoral perspective (Section 4). I first look at the comparative growth performance of the EU manufacturing sector in global perspective. Then I discuss the key role for market services in understanding Europe's underperformance relative to the United States. In the final section, I focus on the question whether the European Union should change or intensify its strategies to revive productivity growth (Section 5). I argue that policy mechanisms, such as macroeconomic management, existing innovation and reform policies and some horizontal policy measures (in particular education policies) should be reconsidered for their effects on the allocation of resources and their effects on productivity at industry and aggregate levels of the economy.

2. Comparative Productivity and Labour Market Performance

Table 1 shows the growth rates of per capita income (measured as GDP per capita) and labour productivity (measured as GDP per hour worked) for major regions in the world economy with a breakdown to individual European countries. The table shows a large variation in per capita income and productivity growth rates in European countries. Within the ‘old’ EU-15, the variation of productivity growth is between 0% (for Spain) and 4.7% (for Ireland) between 1995 and 2004. Productivity growth in the new member states is higher but also varies much between -0.4% (Malta) and 11/5% (Lithuania) from 1995-2004.

On average EU labour productivity growth is not only slower than in the U.S., but also compared to Japan and other OECD countries (not shown in the table). In terms of GDP per capita growth, the differences are not as big. Between 1995 and 2004 EU-25 per capita income growth was only slightly lower than in the U.S. and substantially higher than in Japan. Compared to China and India, all countries except the Baltic states fall short. But it should be stressed that the absolute income levels in these two Asian countries are substantially below those of the advanced nations, suggesting a large ‘catch-up’ bonus which is still to be realised (see Table 2).

GDP per capita growth is driven by an increased input of labour and/or labour productivity growth. Indeed one can simply show that the *difference* in the growth rates of average per capita income and labour productivity can be accounted for by changes in a range of labour market and population indicators (see van Ark and McGuckin, 1999; McGuckin and van Ark, 2005a). First, the growth in income per head of the population ($\Delta O/P$) is a function of the change in labour productivity ($\Delta O/H$) and labour intensity, expressed as the number of working hours per head on the population ($\Delta H/P$):

$$\Delta O/P = \Delta O/H * \Delta H/P \quad (1)$$

The change in working hours per person can be decomposed into the change in hours worked per person employed *(H/E)* and the change in the share of employment in the total population *(E/P)*:[3]

$$\Delta H/P = \Delta H/E * \Delta E/P \quad (2)$$

Table 2 shows the breakdown of per capita income into labour market indicators and productivity from the perspective of *comparative levels* of European countries relative to the United States for 2004. The estimates are converted on the basis of purchasing power parities, which take account of differences in relative price levels across countries. In addition to Europe, comparative estimates are also shown for Japan, Mexico, China and India.

It is clear from Table 2 that the comparative levels of labour productivity in the ‘old’ EU-15 countries were substantially higher relative to the United States than the relative per capita income levels. This is mainly due to the substantially lower number of working hours per employed person and, in addition, to a lower ratio of employed persons relative to the total population.

[3] The change in the employment/population ratio (E/P) can be further broken down into the number of persons employed relative to the total labour force (i.e., employed persons plus registered unemployed persons) (E/L), the ratio of the labour force to all persons aged 15 to 64 (i.e., the working age population) (L/P1564) and the share of the working age population in the total population (P1564/P): $\Delta E/P = \Delta E/L * \Delta L/P1564 * \Delta P1564/P$ (see see van Ark and McGuckin, 1999; McGuckin and van Ark, 2005a)

Table 1: Growth Rates of Per Capita Income and Labor Productivity Growth, 1987-2004

	GDP per capita			*GDP per hour worked*		
	1987-1995	1995-2004	of which 2000-2004	1987-1995	1995-2004	of which 2000-2004
EU-15[a]	1.8	2.0	1.3	2.3	1.4	1.1
Austria	2.1	2.0	1.0	2.3	2.4	1.3
Belgium	2.1	1.9	1.2	2.3	1.6	1.3
Denmark	1.3	1.7	1.1	2.1	1.7	1.9
Finland	0.3	3.4	2.1	2.8	2.5	2.2
France	1.5	1.8	1.2	1.9	1.8	1.9
Germany	1.8	1.2	0.5	3.1	1.9	1.3
Greece	1.2	3.6	4.0	0.8	2.7	2.8
Ireland	5.1	6.6	4.0	4.0	4.7	3.5
Italy	1.8	1.3	0.8	2.0	0.4	-0.2
Luxembourg	3.9	3.7	1.5	2.6	2.0	1.2
Netherlands	2.0	1.7	0.0	1.6	0.4	0.4
Portugal	3.1	2.0	0.0	2.8	1.4	0.3
Spain	2.5	3.2	2.6	2.1	0.0	0.2
Sweden	0.6	2.5	1.8	1.4	2.4	2.4
U.K.	1.7	2.5	2.0	2.1	2.0	2.0
EU-10, new[b]	--	3.9	3.6	--	4.2	4.5
Cyprus	--	2.8	2.4	--	2.0	1.4
Czech Republic	--	2.3	3.2	--	3.2	4.4
Estonia	--	6.6	7.0	--	7.1	6.6
Hungary	--	4.1	3.9	--	2.7	3.2
Latvia	--	7.3	8.4	--	6.1	7.3
Lithuania	--	5.9	7.7	--	7.6	11.5
Malta	--	2.3	-0.4	--	2.1	-0.4
Poland	--	4.1	2.9	--	4.8	4.3
Slovakia	--	4.0	4.5	--	4.2	4.6
Slovenia	--	3.8	3.3	--	3.1	2.8
EU-25, enlarged[c]	--	2.1	1.5	--	1.8	1.6
United States	1.5	2.3	1.6	1.1	2.5	2.9
Japan	2.6	1.0	0.9	2.8	2.1	1.9
Mexico[d]	0.4	2.2	-0.5	0.6	0.3	0.9
India[d]	3.9	4.5	5.2	3.7	3.9	3.1
China[d]	5.7	6.6	7.7	4.7	6.1	6.8

a) referring to membership of the European Union until 30 April 2004; b) referring to new membership of the European Union as of 1 May 2004; c) referring to all members of the European Union as of 1 May 2004 (see Table 2): d) productivity in China is in terms of GDP per person employed
Source: TCB/GGDC Total Economy Database (www.ggdc.net/dseries), based on OECD National Accounts and Labour Force Statistics

Table 2: Labour Productivity and Income: Differences in Ranking, 2004

	Productivity (per hour)		Effect of Working Hours	Productivity (per worker)		Effect of Employment/ Pop. Ratio	Per Capita Income	
	US$	%US		US$	%US		US$	
EU-15[a]	40.51	91%	-13%	63311	78%	-6%	27666	72%
Luxembourg	56.84	128%	-24%	83959	104%	37%	53993	141%
France	50.08	113%	-24%	72065	89%	-14%	28956	76%
Belgium	48.12	109%	-13%	76890	95%	-18%	29826	78%
Ireland	46.26	104%	-10%	76274	95%	-3%	35021	91%
Netherlands	44.48	100%	-26%	60278	75%	3%	29766	78%
Austria	43.81	99%	-17%	65646	81%	-2%	30466	79%
Germany	43.22	97%	-20%	62349	77%	-7%	27076	71%
Denmark	41.65	94%	-17%	62364	77%	3%	30746	80%
Finland	39.60	89%	-8%	65414	81%	-4%	29545	77%
U.K.	39.28	89%	-10%	63676	79%	-1%	29935	78%
Italy	39.27	89%	-11%	62930	78%	-8%	26714	70%
Sweden	39.24	88%	-12%	61789	77%	0%	29517	77%
Spain	32.59	73%	-1%	58583	73%	-8%	24763	65%
Greece	28.14	63%	3%	53978	67%	-11%	21326	56%
Portugal	22.53	51%	-3%	38715	48%	1%	18909	49%
EU-10, new[b]	18.18	41%	3%	35729	44%	-8%	13817	36%
Malta	26.76	60%	4%	52124	65%	-17%	18105	47%
Slovenia	25.65	58%	5%	50812	63%	-9%	20592	54%
Cyprus	22.72	51%	8%	47836	59%	-8%	19814	52%
Hungary	22.46	51%	0%	40563	50%	-10%	15589	41%
Czech Republic	20.55	46%	3%	39430	49%	-2%	18027	47%
Slovakia	17.62	40%	3%	34508	43%	-7%	13805	36%
Poland	17.16	39%	3%	34029	42%	-10%	12169	32%
Lithuania	13.57	31%	6%	29402	36%	-6%	11779	31%
Estonia	13.12	30%	4%	26895	33%	-3%	11521	30%
Latvia	10.99	25%	4%	23593	29%	0%	11172	29%
EU-25, enlarged[c]	36.51	82%	-9%	59236	73%	-7%	25397	66%
United States	44.34	100%	0%	80660	100%	0%	38345	100%
Japan	32.74	74%	-3%	57263	71%	3%	28460	74%
Mexico	13.46	30%	5%	28400	35%	-10%	9598	25%
India[d] (2003)					9%	-2%		7%
China[d] (2003)					14%	2%		15%

a) referring to membership of the European Union until 30 April 2004 (see Table 1)

b) referring to new membership of the European Union as of 1 May 2004 (see Table 1)

c) referring to all members of the European Union as of 1 May 2004 (see Table 1)

d) no productivity (per hour) available. Output converted to US$ at 1990 GK PPPs. Figures refer 2003

Source: TCB/GGDC Total Economy Database (www.ggdc.net/dseries), based on OECD National Accounts and Labour Force Statistics, with GDP converted to US$ at 2002 EKS PPPs.

The relative high levels of labour productivity in Europe have been pointed at by various scholars as an indication of a "European model" that deals differently with the trade-off between labour intensity and productivity than the U.S. model. According to, for example, Blanchard (2004) and Gordon (2004) the European preference for more leisure would be offset against a lower level of per capita income. Moreover, Gordon argues that a significant portion of higher American GDP per capita is required to create decent living conditions in a much harsher natural environment (requiring a greater use of energy for heating and air-conditioning), to fight crime and to travel longer distances across huge metropolitan areas. Prescott (2004) argues that tax systems explain most of the differences in labour supply between Europe and the United States making work more costly relative to leisure. Alesina *et al.* (2005) explain Europe's preference for leisure through the effect of worksharing agreements in declining industries, which have not created more employment but have increased returns to longer vacations leisure through a social multiplier effect.

While there may be some truth in all these arguments, one should be cautious not to speak too easily of one 'European model' for the labour market. Firstly, Table 2 shows large differences in the effects of working hours and participation on per capita income. For example, participation effects are much more negative in Belgium, France and Greece than in Denmark, the Netherlands and Sweden. In contrast, average working hours are much higher in the Southern European states than, for example, in France, Luxembourg and the Netherlands. Secondly, Sapir (2005) clearly indicates that Europe may be characterized by at least four social models, distinguished by region (Nordic, Anglo-Saxon, Continental European and Mediterranean). Thirdly, and in line with Table 2 and Sapir's observations, European countries have made progress to different degrees in terms of raising labour participation substantially during the 1990s.

In reality, slow productivity growth due to increased participation is primarily a short term phenomenon. For example, in an extensive empirical study for almost all OECD countries, McGuckin and van Ark (2005b) find that the negative productivity response elasticity to a 1% rise in participation is less than 0.3 and peters out in less than five years. A too strong focus on the 'trade-off' issue can easily lead to the mistaken view that this is a predetermined reality for Europe in the coming decades. The main source of productivity differentials between countries in longer run, however, is not due to a lack in terms of work effort but primarily because of an underperformance of capital and technology, which is the focus of the next Section.

3. The Differential in Sources of Growth between Europe and the U.S.

Labour productivity growth can be decomposed into the contributions of capital and technology using a growth accounting framework (Solow 1957, Jorgenson 1995). Although such decompositions are only possible on the basis of certain assumptions, cost-minimizing producers, competitive factor markets, well-measured inputs and output, and constant returns to scale (which are unlikely to be fully satisfied), it provides a simple and consistent method which can used as a starting point to identify the contributions of the source of growth.

In the decomposition below, we focus explicitly on the contributions of Information and Communication Technology (ICT) to productivity. As a General Purpose Technology, ICT may be expected to have a long-lasting effect on productivity growth, and it may therefore be a possible source of productivity differentials between countries in the longer run. The contribution of ICT to productivity can be traced through three transmission channels, namely through investment in ICT, the production of ICT, and possible "spillovers" from the use of ICT. In a neo-classical framework, the contribution from ICT investment is well defined: firms will invest in ICT up to the point where further output gains are equal to the marginal cost of the investment. This way the contribution from growth in ICT capital per hour worked to labour productivity growth can be identified. Total factor productivity (TFP) growth in ICT producing industries will quite naturally contribute to aggregate TFP growth and hence labour productivity growth. The final channel, which is TFP growth due to ICT use, is the hardest to identify separately and it also raises some conceptual issues. The underlying idea of spillovers from ICT, is that ICT enables new organizational models and other innovations in the production process, as well as the production of new goods and services. So although new ICT investment goods are standard products, they make it possible for firms to innovate and accumulate firm-specific capital (see e.g. Brynjolfsson and Hitt, 2000 and OECD, 2004). Insofar as these innovations yield additional output gains, they may show up as additional total factor productivity growth in ICT using industries and may be labelled as "spillovers".

Gross domestic product (*Y*) is produced from aggregate factor inputs *X*, consisting of ICT capital services (K_{ICT}), non-ICT capital services (K_N) and labour services (*L*). Total factor productivity (*A*) is represented as a Hicks-neutral augmentation of the aggregate inputs. The aggregate production function has the following format:

$$Y = AX\left(L, K_N, K_{ICT}\right) \tag{3}$$

Under the assumption of cost-minimizing producers, competitive factor markets and constant returns to scale, total factor productivity growth is derived as the growth of output minus a share weighted growth of inputs:

$$\Delta \ln A = \Delta \ln Y - \bar{v}_L \Delta \ln L - \bar{v}_N \Delta \ln K_N - \bar{v}_{ICT} \Delta \ln K_{ICT} \tag{4}$$

where Δ refers to first differences and $\bar{v}$'s denote the two-period average shares in total factor income and because of constant returns to scale: $\bar{v}_L + \bar{v}_N + \bar{v}_{ICT} = 1$. By rearranging equation (4) average labour productivity growth, defined as $y = Y/L$, can be decomposed into the ratio of capital services to hours worked, $k = K/L$, and TFP growth. Another useful distinction can be made between TFP growth originating in manufacturing industries producing ICT goods (A_{prod}) and that from other industries, 'other' TFP (A_{other})

$$\Delta \ln y = \bar{v}_N \Delta \ln k_N + \bar{v}_{ICT} \Delta \ln k_{ICT} + \Delta \ln A_{prod} + \Delta \ln A_{other} \tag{5}$$

The estimates on the comparative growth performance of the EU-15 and the U.S. presented here are an update to 2001-2004 from earlier work by Timmer and van Ark (2005). Data on investment, GDP and labour compensation are typically derived from national accounts. However, substantial additional work was required to construct separate investment time series for three ICT assets (office and computing equipment, communication equipment, and software) as well as three non-ICT assets (non-ICT equipment, transport equipment and non-residential structures). The resulting real investment series are used to derive capital service growth rates which, in combination with growth rates on total hours by employees (mainly obtained from labour force surveys), give the growth of capital services per hour worked. The contribution of each capital asset to growth was estimated using the share of capital compensation of each asset in total GDP as weights. Aggregate total factor productivity growth (TFP) was derived as a residual from labour productivity growth minus the contribution of capital deepening to GDP growth. To obtain separate TFP estimates for ICT-producing industries from 'other' TFP, we assume that TFP growth rates for each of the three ICT-industries (office, accounting and computing equipment, communication equipment and electronic components manufacturing) in the U.S. also apply to the European countries.[4] To measure the ICT industry contributions to total factor productivity growth, Domar weights for the individual countries were used.[5]

Table 3 presents the results for the EU-15 and the U.S. for the periods 1987-1995, 1995-2000 and (the updated period) 2000-2004. The tables shows a decomposition of labour productivity growth into the effects of ICT capital deepening and TFP growth from ICT-producing industries, and two other sources of growth, namely non-ICT capital deepening and TFP growth other than that from ICT production. Our main findings are that the EU-15 as a whole has been lagging behind the U.S. in terms of ICT capital deepening throughout all periods. Both the EU-15 and the U.S. show a strong acceleration of ICT capital deepening during the late 1990s. However, this investment boom was mostly transitory, with ICT capital deepening returning to pre-1995 levels after 2000 in both the EU-15 and the U.S. However, since 2000 U.S. labour productivity accelerated further, while the EU-15 suffered additional slowdown. This divergence

[4] Of course one would ideally use capital service measures at the industry level for individual European countries. To date such detailed TFP estimates are only available for the U.S. and a few European countries. We use these more detailed estimates in Section 4.

between the Europe and America mainly relates to TFP growth outside the ICT producing sector. In Europe, TFP growth in outside ICT-production was effectively zero after 2000, while in the U.S. 'other' TFP growth added almost 1.5 percentage points to labour productivity growth.[6]

Table 3: Sources of labour productivity growth in the EU-15 and U.S., 1987-2004

	1987-1995	1995-2000	2000-2004*
European Union-15			
Aggregate Labour Productivity Growth	2.3	1.8	1.1
of which:			
ICT capital deepening	0.4	0.6	0.3
Non-ICT capital deepening	0.8	0.4	0.5
ICT-production TFP	0.2	0.4	0.2
Other TFP	0.9	0.4	0.0
United States			
Aggregate Labour Productivity Growth	1.2	2.3	2.8
of which:			
ICT capital deepening	0.5	1.0	0.6
Non-ICT capital deepening	0.1	0.2	0.5
ICT-production TFP	0.4	0.7	0.3
Other TFP	0.2	0.4	1.4

* 2004 is preliminary estimate based on average share of ICT investment in total investment for 2002 and 2003

Source: Van Ark and Inklaar (2005)

On the basis of this evidence, it may be hypothesized that the faster growth and acceleration in 'other' TFP in the United States may be due to a greater degree of spillovers created by the use of ICT. However, one has to be very cautious in interpreting this evidence. Firstly, there is no strong statistical evidence about a positive relationship between ICT capital deepening and 'other' TFP (Stiroh, 2002; Van Ark and Inklaar, 2005). Secondly, there are many more differences that affect TFP growth differences between countries such as, for example, differences in market structure and flexibility of

[5] The Domar weight of an industry is defined as the industry's gross output divided by aggregate value added. In general, these weights sum to more than one.

[6] Estimates for individual countries can be obtained from http://www.ggdc.net/dseries/growth-accounting.html. Although there is much variation in TFP not related to ICT, the trend is generally downwards with the exception of Sweden and the United Kingdom.

product, labour and capital markets between countries.[7] Thirdly, without TFP growth estimates for individual industries there is no good way of identifying such spillovers, as the aggregate TFP residual may include a whole range of unmeasured contributions (or detractions) to output growth which are difficult to distinguish at aggregate level. Hence the next Section of this paper focuses on industry estimates of productivity growth.

4. An Industry Perspective on Productivity Growth

In this section we look at productivity performance from an industry perspective. Although many of the policy issues related to the slowdown of productivity growth in Europe are more of a generic nature rather than industry specific, the sector perspective is useful for several reasons. Firstly, it is important to pinpoint in which industries or industry groups the slowdown occurs and to examine whether it is confined to a few sectors or whether it is more widespread. Secondly, under the influence from both intra-EU economic integration and the on-going globalization of product markets and factor markets, the industry structure is under continuous pressure from competitive forces. It is important to establish how these changes have affected the overall performance of the economy. Finally, the opportunities for new technological applications may have very different implications for industries. Indeed the absorptive capacity for ICT differs highly across industries, and has very different impacts on output, employment and productivity performance.

For an analysis of productivity growth in Europe and the U.S. at industry level, the GGDC developed a database which contains information on value added and employment by industry (see van Ark *et al.*, 2003a; O'Mahony and van Ark, 2003). This so-called '60-industry database' has been updated to the year 2003.[8] On the basis of this

[7] See, for example, Hall (1988) and Roeger (1995).
[8] The updated measures will be released on the GGDC website (www.ggdc.net/dseries/60_Industry.shtml) in November 2005. The main source of this database is the new OECD STAN Database of national accounts, but greater industry detail is provided through the use of industry surveys and censuses. As discussed above, we ultimately would like to have estimates of TFP growth for individual industries, in addition to the aggregate figures presented above. Only then it is possible to see which industries are heavy ICT investors and whether these industries have higher TFP growth. This can help determine whether ICT spillovers are an important source of growth differences between Europe and the United States. At this

dataset, measures of labour productivity growth and the contribution of individual industries to aggregate productivity growth can be calculated. These contributions are calculated using a shift-share approach. Table 4 summarizes the contributions of three major industry groups (ICT-producing industries, other producing industries and other market services) and a reallocation effect to labour productivity growth in the market sector of the economy.[9]

Table 4: Industry contributions to market economy labour productivity growth, 1987-2003

	1987-1995	1995-2000	2000-2003
European Union-15			
Market economy labour productivity growth	2.7	2.2	1.1
of which:			
ICT production*	0.5	0.8	0.5
Production industries**	1.3	0.8	0.6
Market services**	0.8	0.6	0.1
Reallocation	0.2	0.0	-0.1
United States			
Market economy labour productivity growth	1.4	3.4	3.6
of which:			
ICT production*	0.8	1.2	1.1
Production industries**	0.3	0.5	0.9
Market services**	0.5	1.8	2.0
Reallocation	-0.2	-0.1	-0.3

* Includes ICT manufacturing, telecom and software services
** Excludes ICT producing industries
Source: Van Ark and Inklaar (2005)

Table 4 shows that differences in the performance of ICT-producing industries (which include ICT-producing manufacturing and services industries) explain part of the aggregate productivity growth differential between Europe and the U.S.

moment such estimates are only available for four major European countries (France, Germany, the Netherlands, the UK) and the U.S.. See also below (Table 8) and Inklaar et al. (2005) and Van Ark and Inklaar (2005).

[9] The ICT producing industries include producers of IT hardware, communication equipment, telecommunications and computer services (including software). The distinction is based on an OECD classification (see OECD 2002).

The larger contribution from ICT production in the U.S. is primarily due to the greater share of ICT producing industries in U.S. value added (the 'between industry' effect). Although productivity growth rates for ICT producing industries (the 'within industry' effect) are roughly the same between the EU-15 and the U.S., 12.6 per cent of U.S. value added in the market economy consists of ICT production, including IT hardware, communication equipment, telecommunications and computer services (including software), compared to 5.3 per cent in the EU-15. This equals 2.7 per cent and 1.5 per cent of value added in the manufacturing sector of the U.S. and the EU-15 respectively

There is no role for other production industries, which mainly includes manufacturing (excluding ICT production), in explaining the aggregate growth differential. Instead, most of the labour productivity acceleration in the U.S. can be traced to faster productivity growth in other market services. This difference has become even more striking since 2000: the contribution of other market services to labour productivity growth almost disappeared in the EU-15 whereas it accelerated further in the U.S.

For Manufacturing, Europe Should Look Towards the East

When focusing on manufacturing, however, it is not sufficiently informative to focus the comparison only on Europe versus the United States. Table 5 looks at comparative productivity performance in aggregate manufacturing for the EU-15, Japan and the United States, and the new EU-10 member states, India and China from 1987-1995 and from 1995-2003. The figures show a clear dichotomy between the advanced and the emerging economies. The EU-15, Japan and the United States show productivity growth rates of between 3 and 4 per cent (although the U.S. shows a strong acceleration after 1995) and the new EU-10 countries, India and China which all show productivity of between 6 and 8 per cent. Hence it is not only wage competition but also 'productivity competition' that the advanced countries are faced with.

Table 5: Manufacturing value added per hour worked, annual average growth rates

	Advanced economies		
	EU-15	USA	Japan
1987-1995	4.0	2.9	3.9
1995-2003	3.2	4.7	3.8
	Emerging economies		
	new EU-10[a]	China[b]	India[b]
1987-1995		6.5	5.7
1995-2003	6.5	8.2	6.1

a) Average for Czech Republic, Hungary, Poland and Slovakia; b) per person employed, 1987-1994 and 1994-2002

Source: TCB/GGDC and OECD STAN database

Table 6 compares relative levels of manufacturing productivity for the same three advanced and three emerging economies as in Table 5. The table shows that productivity levels in the emerging economies are considerably lower than in the advanced economies: the three new EU member states in Central & Eastern Europe perform at about 20 per cent of the U.S. manufacturing productivity level which equals 26 per cent of the EU-15 productivity level. In India and China, productivity in manufacturing is a fraction of that in the advanced world, i.e. 2 per cent of the U.S. level in India and 5 per cent of the U.S. level in China.

However, as manufacturing goods are primarily tradeables it is useful to compare not only productivity but also the cost of inputs in the production process. A well-known measure of international competitiveness combines labour cost and productivity into a single measure of labour cost per unit output. Unit labour cost is defined as the cost of labour required to produce one unit of output. As wage cost in the emerging economies are also lower than in the advanced countries, the differences in terms of unit labour cost are much smaller than for productivity. Table 6 shows that lower labour compensation more than offsets lower productivity levels in the emerging economies. As a result, the manufacturing cost competitiveness in the advanced economies is considerably worse than in the emerging economies.

Table 6: Manufacturing Value Added per Hour Worked and Unit Labour Cost, annual average growth rates (USA=1.000)

	Value added per hour worked (PPP adjusted)	Unit Labour Cost (exchange rate adjusted)
	Advanced economies	
EU15	0.788	0.905
Japan	0.661	1.195
USA	1.000	1.000
	Emerging economies	
New EU-10[a]	0.205	0.724
China[b]	0.043	0.495
India[b]	0.053	

a) Average for Czech Republic, Hungary, Poland and Slovakia; b) productivity (per person employed)
Source: TCB/GGDC and OECD STAN database

Indeed it is questionable whether advanced countries can ever compete solely on costs. Hence the call for an acceleration of R&D investment (for example, the 3% R&D intensity target for the EU) and for more innovation in general seems to be the obvious way forward for manufacturing activity in advanced countries. However, even in this area advanced countries face increased competition from emerging economies. Recent OECD figures on the number of researchers, for example, show that China already has almost 900 thousand researchers as compared to 1.3 million researchers in the U.S., 1 million in the EU-15 and 650 thousand in Japan. The share of researchers in total employment in still highest in Japan and the U.S., but the Russian Federation, Korea and Taiwan already show a higher researcher intensity than the EU-15. The share of business enterprise researchers in the total number of researchers is highest in the U.S., Japan and Korea, but comparable between China, the EU-15 and the Russian Federation (OECD, 2005).

In sum, manufacturing competition from emerging economies is not exclusively a cost matter, but also related to the capabilities of economies to generate innovation and raise R&D. In this respect, Europe is in a somewhat disadvantageous position relative to other advanced economies, because it has a lower value added share in high-tech activities, such as ICT, pharmaceuticals, etc., against a higher share in medium-tech industries, such as machinery and transport equipment (O'Mahony and van Ark, 2003).

For Services, Europe Should Look Towards the West

Table 4 has shown that market services account for the largest part of the EU15-U.S. productivity growth gap since 1995. It is therefore important to get a better understanding of the sources of the much faster productivity growth in market services in the United States relative to the EU-15.

To get a clearer view on this, we first look in some more detail at the contribution from individual market services industries to the aggregate EU15-U.S. productivity growth gap in the market economy. Here one can distinguish again between a 'within industry' effect due to faster productivity growth in the U.S. than in the EU, and a 'between industry' effect which relates to a higher share of rapidly growing industries in the U.S..

Table 7 shows that most of the difference in market services productivity growth between 1995 and 2003 can be traced to six industries, concentrated in trade and finance industries. Part of the difference can be explained by the fact that wholesale trade, retail trade and securities trade are larger sectors in the U.S. than in Europe, but faster productivity growth within each industry is by far the most important factor. For Europe, there is only a limited compensation due to faster productivity growth in European telecommunication industries and construction. Furthermore despite faster productivity growth in U.S. banking, the somewhat lower share of this sector in Europe partly offsets this effect. Since 2000 (not shown separately in the table) the contribution of business services to aggregate productivity growth has also improved in the U.S.. In contrast, in European countries these service industries mostly show a productivity slowdown – or at best stability – since 2000.

Table 7: Percentage Point Contribution of Market Service Industries to Productivity Growth Gap between EU15 and the United States, 1995-2003

	%-point contribution to productivity gap	of which	
		within industry ('productivity') effect	between industry ('share') effect
Wholesale trade	0.387	0.315	0.073
Retail trade	0.296	0.269	0.027
Securities trade	0.361	0.244	0.117
Banking	0.181	0.230	-0.049
Other business services	0.113	0.113	0.000
Motor vehicle trade	0.108	0.085	0.023
Professional services	0.068	0.067	0.001
Hotels & catering	0.051	0.052	-0.001
Transport services	0.032	0.051	-0.020
Air transport	0.048	0.037	0.010
Renting of mach. & eq.	0.017	0.032	-0.015
Computer services	0.022	0.016	0.006
R&D	0.000	0.000	0.000
Social & personal services	-0.006	-0.005	-0.001
Inland transport	-0.024	-0.014	-0.010
Water transport	-0.030	-0.018	-0.012
Insurance	-0.037	-0.019	-0.019
Communications	-0.014	-0.059	0.045
Construction	-0.068	-0.064	-0.004

Source: Van Ark and Inklaar (2005)

Unfortunately our knowledge about why these large differences in productivity growth between the EU15 and the U.S. arise is still limited. Van Ark (2005) investigates the validity of a number of explanations including (1) problems with the measurement of service performance, (2) a genuine shortfall in innovative capacity of service industries in Europe, and (3) a lack of reforms to exploit the productivity potential of service innovation. Below follows a brief summary of these sources of uncertainty.

Ad 1) Measurement problems in services

In the past few years there have been increasing concerns about whether the macroeconomic statistics correctly trace the changes at industry level. In practice, the quality of measures of output and productivity differs highly across industries and between countries. Griliches (1994) showed a striking difference between the acceleration of labour productivity growth in 'measurable' sectors of the U.S. economy (agriculture, mining, manufacturing, transport and communication, and public utilities) and the slowdown in 'immeasurable' sectors (like construction, trade, the financial sector, 'other' market services and government) over past decades. Apart from an increase in measurement error at the aggregate level due to shift towards the immeasurable sectors of the economy, one may also observe an increase in measurement problems in the 'immeasurable' sector itself. This component of the rise in measurement problems may – at least in part – be related to the increased use of ICT.

In practice the largest measurement problems relate to the measurement of output in the service sector. The current methodology of splitting the change in output value into a quantity component and a price component is difficult to apply to many service activities, as often no clear quantity component can be distinguished. Moreover, possible changes in the quality of services are also difficult to measure. These problems are not new, and improvement in measurement of service output has been a topic on the agenda of statisticians and academics for a long time.[10] In many service industries information on inputs (such as labour income) was and still is used as a proxy for output. However, the increased importance of ICT may have accelerated quality changes in services and raised the potential for productivity growth in services, which was previously not envisaged.[11] However, to include those quality aspects in the output measure, multiple dimensions of a service need to be taken into account, for example, the service concept, the type of client interface and the service delivery system (den Hertog and Bilderbeek, 1999). This implies that the real output of a particular service cannot be measured on the basis of one single quantity indicator. New measurement methods make use of various volume measures in, for example, financial services (e.g, in the Netherlands and in the United States) and health services and other government services (e.g., in the United Kingdom). Even though such changes in measurement methods have not exclusively led to upward adjustments of real output, on balance the bias is probably towards an understatement of

[10] See, for example, Griliches (1992), Wölfl (2003) and Triplett and Bosworth (2004).

the growth in real service output (Triplett and Bosworth, 2004). There is no evidence, however, that this bias is in any way bigger in Europe than in the U.S..

Ad 2) A lack of innovation in services?

It is sometimes claimed in the literature that slower productivity growth in services in Europe is related to a lack of innovation. However, there is little direct evidence to substantiate this claim.

As documented in Section 3, ICT investment is an important enabler of innovation and productivity growth. When focusing on market services it is clear that the U.S. has been more successful in obtaining productivity effects from ICT investment in services than EU. Table 8 shows growth accounting results for five countries (namely France, Germany, The Netherlands, the UK and the U.S.), for which the contribution of market services to aggregate productivity growth can be measured (Inklaar et al., 2005; Van Ark and Inklaar, 2005). The results show that faster labour productivity growth in U.S. market services is partly due to a faster growth in ICT capital deepening in the U.S., but much more so due to an improvement in TFP growth. Since 1995 TFP has contributed as much to labour productivity growth as ICT capital deepening. ICT capital contributes much less to productivity growth in market services in all European countries, and TFP growth is even negative with the exception of the UK.

But what the TFP residual essentially represents has remained somewhat unclear. Clearly it might include the positive effects from unmeasured factor inputs in services, notably the effects from non-technological innovation and intangible investments in human capital, organizational capital and knowledge creation. Indeed the productive use of ICT investment in services is strongly dependent on various dimensions of non-technological innovations.

There are different ways to go about measuring non-technological innovation and its impact on productivity growth. For example, van Ark (2005) looks at ways to organize

[11] See, for example, Baumol (2004) and Triplett and Bosworth (2002).

the industry data on the basis of type of innovation in the industry. A crucial consideration for such a service innovation typology is the way in which suppliers of inputs (machines, computers, and human capital), the service company and its customers (consumers of intermediary users) interact.

Table 8: Contributions of Market Services and Underlying Sources to Market Economy Labour Productivity Growth, 1987-2003

	France	Germany	Nether-lands	United Kingdom	United States
1987-1995					
Market Economy Labour Productivity Growth	2.4	2.6	1.7	3.0	1.4
Contribution of market services	0.5	0.9	0.5	1.0	0.5
of which:					
ICT capital deepening	0.2	0.3	0.3	0.3	0.4
Non-ICT capital deepening	0.2	0.3	0.2	0.5	0.1
Labour quality growth	0.1	0.1	0.1	0.4	0.2
Total factor productivity growth	0.0	0.2	-0.2	-0.2	-0.1
1995-2003					
Market Economy Labour Productivity Growth	1.8	2.1	1.4	2.6	3.5
Contribution of market services	0.1	0.3	0.6	1.3	2.0
of which:					
ICT capital deepening	0.3	0.4	0.6	0.5	0.8
Non-ICT capital deepening	0.0	0.1	0.3	0.4	0.3
Labour quality growth	0.1	0.0	0.1	0.1	0.1
Total factor productivity growth	-0.4	-0.2	-0.3	0.2	0.8

Source: Van Ark and Inklaar (2005)

Using the service innovation typology, Van Ark (2005) showed that the innovation process in services is strongly dependent on innovations by suppliers and users in the value chain. For example, the estimates for the U.S. show a strong acceleration in productivity growth in those services which depend most strongly on innovation by their suppliers. For example, the retail industry has benefited strongly from productive exploitation of ICT. For example, the introduction of barcode scanning allowed for more efficient check-out systems and enabled a reorganization of the supply chain and the introduction of new shopping concepts. ICT also supported the introduction of complementary technologies (such as RFID, transportation technology) and organizational change (new shopping concepts, adjustment in the logistic chain of supplying the shops more frequently, etc.). The strong improvement in U.S. retail trade has also gone together with strong productivity growth in wholesale trade, which explains the U.S. advantage in client led services. These industries benefited from the supply of ICT, but have also undergone significant organizational innovations. Indeed in industries that are primarily characterized by organizational innovations, U.S. performance has also strongly improved, in particular in banking.

Within the EU, the experiences in service productivity growth are mixed across industries and countries (Van Ark et al., 2003a). Although services will be an important engine for future productivity improvements, the exploitation of the potential for productivity growth will be strongly dependent on national circumstances, including the nature of the innovation system and the working of product and labour markets

Ad 3) A lack of market reform in services?

There has been much discussion in the literature about the link between, on the one hand, the performance of product and labour markets and, on the other hand, innovation and productivity. The basic argument has been that regulation restricts competition to a much greater extent in Europe than in the United States. Quantifying these differences is difficult, but a wide variety of evidence suggests that regulation does indeed matter in reducing productivity growth.[12]

However, explaining sluggish productivity growth in Europe by broadly casting it as overregulated and uncompetitive is not very useful analytically. There is much variety and subtlety in the way by which regulation affects service productivity and innovation. It is essential to understand if and how regulation constrains productivity. Instead of giving an overall view of the interaction, it may be preferable to focus on specific industries.

For example, McGuckin *et al.* (2005) provide a detailed discussion of productivity, innovation and regulation in retail trade. The study shows that U.S. retailers and wholesalers have been able to boost their overall operational effectiveness in a way that

[12] See, for example, Nicoletti and Scarpetta (2003).

firms in many European countries have not. U.S. retailing was transformed from a low-technology sector to one of the most intense users of information and communication technologies (ICT). The technologies used in this sector rewarded scale and scope, enabling large centralised chains and big stores to expand rapidly. U.S. firms, which were relatively unaffected by regulation and custom, have taken advantage of the opportunity to combine new technologies and organisational change to generate rapid productivity growth.

European retailers and wholesalers have also been investing in ICT capital at similar rates to U.S. firms in recent years. But the IT share of overall investment is still considerably lower than in the United States. A likely reason is that the incentives to invest in ICT are lower given the burdensome regulatory environment in Europe. There are three categories of regulation that can be logically associated with slow productivity growth in European retailing—store opening hours, land usage restrictions (especially on large stores), and labour laws.

But the situation in Europe is changing rapidly. Product market regulations have been eased in many countries, and competitive incentives for change are increasing. Some of the slow TFP growth of the late 1990s may be due to the actual adjustments being made. As many European countries quickly increase their IT infrastructures, they will be better positioned to exploit the efficiencies of the new retail business models once the effects of deregulation kick in.

In sum, while the overall picture points in the directions of regulations hampering productivity growth in services in Europe, there are many subtleties in how it exactly impacts on productivity growth. There are large differences between EU countries. In fact the lack of a harmonised regulation system in itself is often cited as a major difficulty in building cross-border operations within Europe. It should also be stressed that complete deregulation is not always the best way to raise productivity growth. Moreover, there is a substantial time lag in reforms impacting on productivity. In this respect, it remains an important question whether the European slowdown is just a reflection of a lagged reform process, or that rigid institutions and regulations hamper the adjustment process.

5. Policy issues

On balance, this paper suggests that the European slowdown in productivity growth is a reflection of an adjustment process towards a new industrial structure, which has developed more slowly in the EU than in the U.S.. But with some delay, rapid diffusion of new technology may ultimately facilitate the adjustment process towards a faster growth track in Europe. After all, the United States has also gone through a phase of slow productivity growth during the 1980s.[13] However, an institutional environment that slows down change may hold up the structural adjustment process in Europe and inhibit the reallocation of resources to their most productive uses.

In a market economy the main way for public policy makers to promote and support faster productivity growth is to try and encourage private enterprises to move in a productivity-enhancing direction. Governments can use a mix of four main policy mechanisms, which are only partly directly targeted towards productivity-enhancing measures.

The first mechanism concerns macro-economic management, which influences the relative prices of capital and labour inputs and hence determines the choice of technology. It may be argued that wage moderation policies and active labour market policies (which have been applied in a different mix and intensity in European countries) have lowered the price of labour relative to capital in Europe. Although conclusive evidence on the precise relationship is still lacking, the relative decline in the price of labour may have impacted the slowdown in the growth of the capital-labour ratio during the 1990s. For many European countries this slowdown can be clearly observed and is an important source for the slower growth in labour productivity.

---

[13] See, for example, Dertouzos et al. (1989).

An important explanation for the slowdown in Europe comes from slower growth in total factor productivity, i.e. productivity growth corrected for the change in capital-labour ratios (Timmer and van Ark, 2005). Slow TFP growth may therefore be related to failing innovation. The second policy mechanism, which includes measures directed to support technological change and innovation, is therefore very popular with governments. However, direct support of particular industries or technology areas easily raises questions on whether governments are able to make the right choices. Moreover, the scope to directly influence innovation activities in services is limited, as most innovations arise in the value chain through market interaction between suppliers and clients. Nevertheless it is clear that governments have a responsibility for creating the 'rules of the game' concerning technology creation and diffusion. 'Technology creating' measures are of particular importance for moving the productivity frontier and improving best practices, and include measures such as R&D policy and the creation of effective patent systems. 'Technology diffusing' measures play a major role in reducing the productivity gap between average and best practice firms, including best practices abroad. They involve the facilitating of training programmes, support of innovation platforms and other ways of co-operation between government and business.

The investment decisions concerning tangible and intangible capital, and the (re)allocations of these inputs to business processes, are taken by firms in an environment, governed by markets in which supply and demand for factor inputs (labour and capital markets) and product and services (product markets) are matched. Governments play an important role in setting the 'rules of the game' (or institutions) of these markets, which is the third main policy mechanism. In the past many existing institutional settings or regulatory arrangements have originally been set up with the motivation to smooth the functioning of the markets, by streamlining rules on competition, business conduct, labour markets, consumer protection, public safety, health and so on. However, regulations may have become a drag to the extent that they limit the efficiency of market functioning, reduce entry of new firms and delay exits. There has been an increasing awareness of the need for an innovation-specific focus on (de)regulation and its impact on growth and productivity performance in the knowledge economy. The opportunities to exploit new technologies are to a large extent determined by the regulatory environment. There is much evidence that higher entry and exit rates of firm within industries are supportive of faster productivity growth (OECD, 2003).

Finally, 'horizontal policies', which represent the fourth main policy mechanism, concern policies that are not directly related to innovation, are at least as important to improve service innovation activity. As human capital is a key input in the innovation process, there is a clear role for the government to provide an adequate formal education system. More specifically governments should support a higher education system that has the flexibility to train excellent researchers, to support their mobility, and to allow business to tap into the knowledge of universities and other higher education institutions for commercial purposes. As the evidence from recent OECD statistics shows, emerging economies are becoming important challengers in terms of the competition for talent.

The optimal mix of these four main policy mechanisms is difficult to determine. It depends on such factors as the distance relative to the world technology and/or productivity frontier, which may differ between industries. It may also depend on the state of institutional reform in particular markets. Finally, the nature of the political reality implies that all public policy interventions are likely to involve costs as well as benefits.

The key to productivity improvements, however, is with business itself. For business there is a choice between a strategy focused on cost reductions through scrapping and postponement of investments in new capital goods and intangibles, or by restructuring through upgrading the resources and overcoming the bottlenecks which account for the difference between average and best practice in a given (local) market. Of course, rapid restructuring through cuts has been propagated as the recipe for the recovery of U.S. firms and global firms in general. The fundamental difference is that when such a strategy is pursued in a market environment that is more flexible, it may help to reposition the firm, activate the resources and realize the potential. Another difference between the EU and the U.S. is that when entry and exit of firms is speeded up, the reallocation of resources to its most productive uses is strengthened. Hence in a more flexible market environment the strategy towards restructuring can be more easily aligned with exploiting the potential for growth and reducing the gap between average and best practice through maximizing the returns on investments in high performing capital goods and intangibles.

References

Alesina, A., E.Glaeser and B. Sacerdote (2005), "Work and Leisure in the U.S. and Europe: Why so Different?", Discussion Paper Number 2068, Harvard Institute of Economic Research.

Ark, B. van (2005), "Does the European Union Need to Revive Productivity Growth?", Research Memorandum GD-75, Groningen Growth and Development Centre, May (downloadable from http://www.ggdc.net/pub/gd75.pdf)

Ark, B. van, R. Inklaar and R.H. McGuckin (2003a), " "Changing Gear: Productivity, ICT and Service Industries in Europe and the United States", in J.F. Christensen and P. Maskell, eds., *The Industrial Dynamics of the New Digital Economy*, Edward Elgar, pp. 56-99

Ark, B. van, L. Broersma and P. den Hertog (2003b), "Services Innovation, Performance and Policy: A Review", Research Series No. 6, Strategy, Research & International Co-operation Department, Ministry of Economic Affairs, The Hague.

Ark, B. van and R.H. McGuckin (1999), "International Labor productivity and per capita income," *Monthly Labor Review*, July, pp. 33-41.

Ark, B. van and R.C. Inklaar (2005), 'Catching Up or Getting Stuck? Europe's Troubles to Exploit ICT's Productivity Potential', Research Memorandum GD-79, Groningen Growth and Development Centre, September (downloadable from http://www.ggdc.net/pub/gd79.pdf)

Baumol, W.J. (2004), "Four Sources of Innovation and Stimulation of Growth in the Dutch Economy", *De Economist*, vol. 152, pp. 321 – 351.

Blanchard, O. (2004), "The Economic Future of Europe", *The Journal of Economic Perspectives*, vol. 18, pp. 3-26.

Brynjolfsson, Erik and Lorin Hitt (2000), "Beyond computation: information technology, organizational transformation and business performance", *Journal of Economic Perspectives*, vol. 14 no. 4, pp. 23-48, Fall.

Dertouzos, M.L., R.K. Lester and R.M. Solow (1989), *Made In America. Regaining the Productive Edge*, MIT Press, 3rd edition.

European Commission (2004), *Facing the challenge. The Lisbon strategy for growth and Employment*, Report from the High Level Group chaired by Wim Kok, Brussels.

Gordon, R.J. (2004), "Two Centuries of Economic Growth: Europe Chasing the American Frontier", CEPR Discussion Paper No. 4415, London.

Griliches, Z., ed. (1992), *Output Measurement in the Service Sectors, Studies in Income and Wealth*, Volume 56, National Bureau of Economic Research, Chicago University Press.

Griliches, Z. (1994), 'Productivity, R&D, and the Data Constraint,' *American Economic Review*, vol. 84, no. 1, pp. 1-23.

Hall, Robert E. (1988), The Relation Between Price and Marginal Cost in U.S. Industry. *Journal of Political Economy*, 96(5), 921-47.

Hertog, den P. and R. Bilderbeek (1999), "Conceptualising Service Innovation and Service Innovation Patterns", mimeographed, DIALOGIC, Utrecht. (http://www.eco.rug.nl/GGDC/dseries/SIID_frontpage.shtml)

Inklaar, R.C., M. O'Mahony and M. P. Timmer (2005), 'ICT and Europe's Productivity Performance; Industry-level Growth Account Comparisons with the United States', *Review of Income and Wealth*, 51(4), pp. 505-536

Jorgenson, D.W. (1995), *Productivity, Volume 1: Postwar US Economic Growth*, MIT Press: Cambridge

Jorgenson, D.W. and K. Stiroh (2000), 'Raising the Speed Limit: U.S. Economic Growth in the Information Age', *Brookings Papers on Economic Activity*, vol. 1, pp. 125-211.

Jorgenson, D. W., M. Ho and K. J. Stiroh (2003), Growth of U.S. Industries and Investments in Information Technology and Higher Education. Forthcoming in Corrado, Haltiwanger, and Sichel (eds.) *Measuring Capital in a New Economy*, University of Chicago Press: Chicago

McGuckin, R.H.. and B. van Ark (2005a), *Performance 2005: Productivity, Employment and Income in the World's Economies*, Research Report R-1364-05-RR, The Conference Board, New York

McGuckin, R.H.. and B. van Ark (2005b), "Productivity and Participation: An International Comparison", Research Memorandum GD-78, Groningen Growth and Development Centre, August (downloadable from http://www.ggdc.net/pub/gd78.pdf)

McGuckin, R.H., M. Spiegelman and B. van Ark (2005), *The Retail Revolution. Can Europe Match U.S. Productivity Performance?*, Perspectives on a Global Economy, Research Report R-1358-05-RR, The Conference Board, New York.

Nicoletti, G. and S. Scarpetta (2003), "Regulation, Productivity And Growth: OECD Evidence: OECD Evidence", *Economic Policy*, Issue 36, pp. 9-72.

OECD (2002), Measuring the Information Economy, OECD, Paris

OECD (2003), The Sources of Economic Growth in OECD Countries, Paris.

OECD (2004), *The Economic Impact of ICT, Measurement, evidence and implications*, OECD: Paris.

OECD (2005), OECD Science, Technology and Industry Scoreboard, OECD, Paris.

Oliner, S. D. and D. E. Sichel (2000), 'The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?', *Journal of Economic Perspectives*, vol. 14, pp. 3-22.

Oliner, S. D. and D. E. Sichel (2002), "Information Technology and Productivity: Where Are We Now and Where Are We Going?", *Federal Reserve Bank of Atlanta Economic Review*, 3rd Quarter 2002, 87(3), pp. 15-44

O'Mahony, M. and B. van Ark, eds. (2003), *EU Productivity and Competitiveness: An Industry Perspective. Can Europe Resume the Catching-up Process?*, DG Enterprise, European Union, Luxembourg (downloadable from http://www.ggdc.net/pub/EU_productivity_and_competitiveness.pdf).

Prescott, E. C. (2004) "Why Do Americans Work So Much More Than Europeans?" *Federal Reserve Bank of Minneapolis Quarterly Review*, Vol. 28, No. 1, July 2004, pp. 2–13.

Roeger, W. (1995), 'Can Imperfect Competition Explain the Difference between Primal and Dual Productivity Measures? Estimates for U.S. Manufacturing,' *Journal of Political Economy*, 103(2), 316-30.

Sapir, A. (2005), "Globalisation and the Reform of European Social Models", background document for the presentation at ECOFIN Informal Meeting in Manchester, Bruegel Institute, Brussels.

Solow, R.M. (1957), "Technical Change and the Aggregate Production Function", *Review of Economics and Statistics*, vol. 39 no. 3 pp. 312-320.

Timmer, M.P. and B, van Ark (2005), "IT in the European Union: A driver of productivity divergence?", *Oxford Economic Papers*, vol. 57 no. 4, pp. 693-716.

Stiroh, K.J. (2002b), "Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say?" *American Economic Review*, vol. 92, no. 5, pp. 1559-1576, December.

Triplett, J. and B.W. Bosworth (2002), " "Baumol's Disease" has been Cured: IT and Multifactor Productivity in U.S. Services Industries", Brookings Institution, mimeographed.

Triplett, J. and B. Bosworth (2004), *Productivity in the U.S. Services Sector. New Sources of Economic Growth*, The Brookings Institution, Washington D.C

Wölfl, A. (2003), "Productivity growth in service industries – an assessment of recent patterns and the role of measurement," *STI-Working Paper 2003-07*, (Paris: OECD)