ICT and productivity in Europe and the United States

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Where do the differences come from?

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Abstract

The surge in labour productivity growth in the United States in the late 1990s has prompted much speculation about the capacity of Information and Communication Technologies (ICT) to structurally increase growth. The simultaneous slowdown in productivity growth in the EU suggests the European countries are falling behind. In this paper we will analyse labour productivity growth in 51 industries in Europe and the United States. Using shift-share techniques we identify the industries in which the U.S. has gained a lead and the underlying reasons for this. The results show that the U.S. has grown faster than the EU because of a larger ICT producing sector and faster growth in services industries that make intensive use of ICT. Lagging growth in Europe is concentrated in wholesale and retail trade and the securities industry.

1. *Introduction*

Explosive growth of investment in information and communication technology (ICT) was at the centre of the unrealistic expectations and excessive enthusiasm that surrounded the "new economy." The slowdown in GDP growth and investment in ICT in the United States since 2000 has tempered the hype. But the question how much of the hype was true remains.

It is clear that just as ICT investment boomed, labour productivity growth in the U.S. more than doubled. Productivity growth in the United States accelerated from growth of 1.1 percent in 1990-1995 to 2.5 percent in 1995-2000. In contrast labour productivity growth in most European countries slowed during the second half of the 1990s. The average annual growth rate of labour productivity, measured as value added per person employed, in the European Union fell from 1.9 percent to 1.4 percent over the same period (see Table 1).

The acceleration in productivity growth in the U.S. spurred a burst of academic research on both sides of the Atlantic. Most of the research concluded that ICT was responsible for the acceleration in productivity growth. In Europe attention focused on the slower growth and how much of it could be tied to differences in ICT diffusion. Initial studies at the economy-wide level suggested that slower rates of ICT investment were an important factor in the poorer European productivity performance.[1] In recent work using a much more disaggregated set of data we confirm the slower rate of diffusion.

This paper extends our earlier work on this issue with a new decomposition of productivity growth that identifies the main factors underlying differences between in this case Europe and the United States.[2] The work is based on comparisons of productivity growth in 51 industries in the U.S. and eleven EU countries for the period 1990 and 2000. The results show that the U.S. has grown faster than the EU because of a larger ICT producing sector and faster growth in services industries that make intensive use of ICT. Lagging growth in Europe is concentrated in three primary ICT using industries, wholesale and retail trade and the securities industry. It appears that, not unlike the electric motor, the economic impact of ICT derives from its production but also – and foremost – from its applications to other processes, products and services.[3] In fact, the higher contribution of the ICT producing manufacturing industries in the U.S. is mainly due to differences in the size of the sector (larger employment shares). In contrast, in ICT using

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[1] See, for example, Daveri (2001, 2002) and Schreyer and Collecchia (2002).
[2] The underlying data material and further analysis are described in more detail in van Ark, Inklaar and McGuckin (2002a). The data only refer to output per person employed, as hours at industry level are still largely missing.
[3] See for example Bresnahan and Trajtenberg (1995).

services, the lower European contributions are associated mostly with productivity growth differences. So on the one hand we have aggregate evidence that countries in Europe invest less in ICT (see van Ark 2002b) and this study shows that intensive ICT users have also shown slower growth in Europe. Thus it appears that the slower diffusion of ICT is the principal factor in explaining the lower European productivity growth.

The paper is organized as follows. In the next Section we give a broad overview of the literature on the growth resurgence in the United States. The evidence suggests an important role in the U.S. growth revival for the production and diffusion of ICT throughout the economy. Section 3 broadly describes the construction of the data and introduces the classification of ICT producing, ICT using and non-ICT industries. Section 4 looks at labour productivity growth in Europe and the United States. For further analysis, Section 5 presents shift-share techniques to identify which sectors are mainly responsible for the growth differential between Europe and the U.S. as well as the sources of these differences. Section 6 shows the results of this analysis and Section 7 concludes.

2. The New Economy in the United States

Most researchers in the U.S. agree that the second half of the 1990s saw an uncommon resurgence in productivity growth. After decades of relative stagnation, labour productivity and total factor productivity growth returned to levels only rarely seen since the early 1970s. Jorgenson, Ho and Stiroh (2002) attribute most of this acceleration to faster accumulation of ICT capital in a considerable number of industries like trade and finance. Total factor productivity (TFP) growth also increased, due mainly to faster technological change in the ICT producing industries. These findings are broadly mirrored in other studies (Oliner and Sichel, 2000, 2002). Stiroh (2002) groups U.S. industries into ICT using or non-ICT based on the share of ICT goods in total capital input. Based on this classification he finds that ICT using industries show faster acceleration in labour productivity growth than non-ICT industries.

Studies have also been done into the sources of growth at the firm level. For example, Brynjolfsson and Hitt (2000) survey micro-studies into the effects of ICT on productivity. They find that investment in ICT goods leads to higher productivity, especially if the investment in capital goods is accompanied by investments in organizational change, like reorganizing the supply chain and introducing new workplace methods. Work by McKinsey Global Institute (2001) shows similar results for a selection of industries. They find that investment in ICT goods alone is not enough to reap high productivity growth, but organizational change is needed as well.

Still, how much of the acceleration in productivity growth is sustainable remains to be seen. Gordon (2002) argues that while ICT contributed to U.S. growth both through the production and use of ICT, the increased productivity growth is mainly due to an unsustainable increase in ICT investment. He shows that most of the acceleration would be reversed if ICT investment would return to the rates seen before 1995. Also in another detailed study of industries in the U.S., Triplett and Bosworth (2002) find that services industries exhibit both strongly positive and negative labour productivity growth rates and that ICT is not the only factor in explaining the differences.

Based on these studies, we can conclude that the American growth resurgence is based on more rapid technological change in the ICT producing industries and rapid ICT investment in other parts of the economy. Important services sectors like trade and finance have overall been the main beneficiaries of these investments. However, apart from heavy ICT investment, large complementary investments in intangible assets like the organization of firms were also necessary. While the sustainability of the acceleration is still an open question, it is revealing that while (measured) productivity usually shows some declines in recessions, labour productivity growth in the U.S. in 2001 remained positive at 0.4 percent and growth in 2002 rebounded to 2.8 percent.[4]

3. *Measuring productivity and ICT at the industry level*

For the analysis of productivity growth in Europe and the U.S. we developed a database, which contains information on value added and employment in 16 OECD countries for 51 industries between 1990 and 2000. The main source is the new OECD STAN Database of national accounts. The STAN Database contains information on the most important national accounts variables from 1970 onwards on a common industrial classification.[5] However, for the level of detail used in this paper, only data for the period from 1990 onwards were available so far. The level of detail has to be very high to adequately distinguish between the different ICT producing industries. This group of industries, including producers of IT hardware, communication equipment, telecommunications and computer services (including software), was distinguished based on an OECD classification (see for example OECD, 2002).

Apart from distinguishing ICT producing industries, we also separate the industries that make intensive use of ICT from those that do not. This is a less straightforward undertaking since

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[4] See McGuckin and van Ark (2003).

nearly every part of the economy uses some ICT. Nevertheless research for the U.S. has shown that a binary classification based on ICT intensity has its uses, mainly when the underlying capital data for the other countries are still very noisy.[6] As a measure of ICT intensity, we rely on the share of ICT capital in total capital services in the United States from Stiroh (2002).

There are two reasons for applying the classification based on ICT intensity in the U.S. to all countries. The first has to do with the very limited availability of data on ICT investment by industry outside the U.S., let alone capital stocks and capital services measures.[7] Secondly, given the leading role of the U.S., it is reasonable to assume that the distribution of ICT use in the U.S. presents a set of technological opportunities, which may or may not have been taken up in other countries. Van Ark *et al.* (2002a) show that the rankings of ICT intensity across industries is reasonably similar in the U.S. and Europe. Based on this, the top half of industries is classified as ICT user and the bottom half as non-ICT.[8] We also make a distinction between manufacturing and services industries within each industry. Appendix Table A1 gives an overview of all ICT producing, ICT using and non-ICT industries.

Additional problems in constructing an internationally consistent database are the method of aggregation and the deflation of ICT products. Many countries at present still use fixed-weight (Laspeyres) indices to calculate aggregate value added at constant prices. This can lead to serious substitution bias if the structure of the economy is changing over time. To correct for this problem, chain-weighted indices like the Fisher or Törnqvist are needed. For this database, we use Törnqvist indices to calculate all aggregates. This means that our estimates for GDP will generally not conform to those from national statistical offices, but on the other hand more consistency across countries is achieved.

Another problem is the deflation of ICT goods. It is well known that the capabilities of semiconductors and computers have improved tremendously over the past few decades.[9] Since consumers can buy computers with vastly more computing power at comparable prices, the price of computing power has declined continuously. However, traditional methods of sampling and calculating price indices for these goods will almost certainly underestimate the rate of price

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[5] The STAN Database uses the international classification ISIC revision 3. This classification is very similar to the one European countries are using, but especially in the U.S., much effort has to be put into reconciling differences in industrial classification, see Appendix B of van Ark *et al.* (2002a).
[6] See McGuckin and Stiroh (2001) and Stiroh (2001).
[7] See van Ark *et al.* (2002b) for some of the difficulties in acquiring ICT investment even for the aggregate European economies.
[8] The exceptions are education and health which rank fairly high in terms of the ICT investment share, but near the bottom on alternative measures such as ICT capital per worker or unit of output. Results are qualitatively similar if these industries were included as ICT using, however.
[9] See Nordhaus (2001) for a long-term perspective on the increase in computing power.

decline and through that, the rate of productivity growth. At present there are only a few countries, like the U.S., Canada and France that have an adequate system in place for measuring prices of computers and semiconductors. This means that measured productivity growth in all other countries is likely to be biased downwards. We avoid this downward bias by applying the U.S. deflators for each of the ICT producing manufacturing industries to all other countries after making a correction for the general inflation level.[10] Although this of course influences the productivity growth rates in the ICT producing industries, Table 1 shows that it does not have a large effect on the aggregate growth figures due to the relatively small weight of this sector in the total economy.

4. *What about Europe?*

The latter half of the 1990s showed a decline of labour productivity growth in Europe while growth in the U.S. accelerated. This suggests Europe has not benefited from ICT to the same degree as the United States. In general, European countries are also heavily investing in ICT equipment, but the investment is taking place at a much slower pace as has been shown most recently in van Ark, *et al.* (2002b).[11] While ICT investment (including software) accounted for 17 percent of business investment in Europe in 2000, the corresponding figure for the U.S. was almost 30 percent. By then the U.S. had further increased its lead compared to 1990 when ICT investment was only 12 percent in Europe and 23 percent in the U.S. The result is that ICT contributes nearly twice as much to labour productivity growth in the U.S. as in the EU.[12]

However, these results refer only to the aggregate economies. To better understand the sources of the aggregate growth differential we focus on the industry perspective. Table 1 provides an overview of the growth experience in Europe and the United States. This Table shows labour productivity growth for the economy as a whole and for several industry groups. Apart from distinguishing between ICT producing, ICT using and non-ICT industries, we also look separately at manufacturing and services industries.

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[10] The inflation level is measured here as the change in the deflator of all industries except the ICT producing manufacturing industries. This procedure is similar to that in Schreyer (2000, 2002), which was applied to ICT deflators for investment. The ICT deflators by industry had to be specifically constructed because implicit value added deflators are not available from the U.S. National Income and Product Accounts at the requisite detail. In the construction of these deflators not only the output price but also changes in intermediate input prices were taken into account (so-called double deflation). See van Ark *et al.* (2002a) for more details and Triplett (1996) for the importance of double deflation in the computer and semiconductor industries.

[11] Similar but less extensive evidence is also provided in for example Colecchia and Schreyer (2002) and Daveri (2001, 2002).

Table 1 shows a number of interesting differences between the EU and the U.S. In the ICT producing manufacturing industries, the U.S. has a clear edge with much higher productivity growth in both periods. However, in Europe productivity growth is also highest compared to the other industry groups. The latter result is partly due to the application of U.S. hedonic price indices to European industries. However, as the two pro-memoria lines in Table 1 show, this picture would hold even using national deflators.

Another remarkable feature is the strong acceleration in productivity growth in ICT using services in the U.S. Before 1995, productivity growth in ICT using services was about similar in the U.S. and in Europe at one to two percent a year. After 1995, however, growth in the U.S. accelerated from 1.9 percent to 5.4 percent on average. Considering that this industry group accounts for more than a quarter of U.S. GDP, the effects on aggregate growth are large.

Finally, both the ICT producing and the ICT using industries show generally faster productivity growth than the non-ICT industries, and this is especially pronounced in the services industries.

5. *Decomposing productivity growth differences*

To get a more quantitative picture of the contribution of an industry to aggregate productivity growth, we employ shift-share analysis at the detailed level of 51 industries. Aggregate productivity is determined by the productivity levels of the individual industries, weighted by each industry's share in total employment:

$$P = \frac{Y}{L} = \sum_{i=1}^{n} \left(\frac{Y_i}{L_i} \right) \left(\frac{L_i}{L} \right) = \sum_{i=1}^{n} \left(P_i \, S_i \right) \qquad (1)$$

In this equation, P is productivity, Y is value added and L is labour input and subscript i denotes the industry. In a time perspective for country A, equation (1) becomes:[13]

$$\frac{P_t^A - P_{t-1}^A}{P_t^A} = \frac{\Delta P^A}{P_t^A} = \sum_{i=1}^{n} \frac{\Delta P_i^A \cdot \bar{S}_i^A}{P_t^A} + \sum_{i=1}^{n} \frac{\bar{P}_i^A \cdot \Delta S_i^A}{P_t^A} \qquad (2)$$

In this equation, a bar over a variable denotes a two-period average. The first term on the right-hand side is generally called the within-industry effect ('intra-effect'), while the second is a between-industry effect ('shift-effect').[14] The first term is the sum of productivity growth for

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[12] This ratio holds for both the contribution from ICT capital deepening and from TFP-growth in the ICT producing industries to labour productivity growth.
[13] See Fabricant (1942).
[14] Van Ark (2001) calls this the 'static-effect.' He also includes a 'dynamic-effect' in his decomposition. It is the product of the growth rate of productivity and of the employment share. However, this effect is very small for short periods (5 years) so it is omitted here.

each industry weighted by the industry's share of employment in the economy. The second term accounts for changes in the industry's share in employment weighted by the industries relative productivity level. Looking at each of the two terms in Equation (2) an industry's contribution will be larger if 1) its productivity growth is higher, 2) its employment share is larger, 3) its employment share grows or 4) its relative productivity level is higher.

This analysis can be carried out for individual countries. But here we use the method to investigate which industries account for the productivity growth differential we have observed between the EU and the U.S. since 1995. For this purpose the shift-share technique needs to be modified somewhat. We propose a novel decomposition that splits up the aggregate productivity growth differential into the difference in contribution of each industry to that differential. The differences in contribution are then attributed to differences in each of the four factors mentioned above.

The comparison starts with the basic shift-share analysis. As in equation (2) for country A, aggregate productivity growth in country B can also be decomposed into industry contributions:

$$\frac{\Delta P^B}{P_t^B} = \sum_{i=1}^{n} \frac{\Delta P_i^B \cdot \overline{S}_i^B}{P_t^B} + \sum_{i=1}^{n} \frac{\overline{P}_i^B \cdot \Delta S_i^B}{P_t^B} \qquad (2')$$

If we want to compare the difference in industry contributions to the aggregate productivity differential between countries A and B, we can simply take the difference of equations (2) and (2'):

$$\frac{\Delta P^A}{P_t^A} - \frac{\Delta P^B}{P_t^B} = \sum_{i=1}^{n} \left(\frac{\Delta P_i^A \overline{S}_i^A}{P_t^A} - \frac{\Delta P_i^B \overline{S}_i^B}{P_t^B} \right) + \sum_{i=1}^{n} \left(\frac{\Delta S_i^A \overline{P}_i^A}{P_t^A} - \frac{\Delta S_i^B \overline{P}_i^B}{P_t^B} \right) \qquad (3)$$

Equation (3) shows that the difference in aggregate productivity growth is due to the differences between countries A and B in the within and shift contributions of each industry. We can take this decomposition one step further and split the difference in within-effect and between-effect into effects which are related to productivity growth (ΔP) or levels ($\overline{P}$) and effects which are related to the employment share ($\overline{S}$) or changes in the share of employment (ΔS) by industry. More precisely, if the within-effect of industry *i* in country A is larger than in B, this can be due to a higher productivity growth or due to a larger employment share over the two periods. Likewise, if the between-effect of industry *i* in country A is larger than in B, this can be due to a bigger change in the employment share or due to a higher productivity level relative to the aggregate productivity level.

To separate these different causes, we define two counterfactual shift-share equations namely by imposing the employment structure of country B on country A and vice-versa. If we impose country B's structure on country A, the two terms on the right-hand side of (2) become:

$$\frac{\Delta P^{A|B}}{P_t^A} = \sum_{i=1}^{n} \frac{\Delta P_i^A \overline{S}_i^B}{P_t^A} + \sum_{i=1}^{n} \frac{\Delta S_i^B \overline{P}_i^A}{P_t^A} \qquad (4)$$

With this first counterfactual the decomposition is carried out as follows:

- The difference between the first term of (4) and the first term of (2') shows the difference in contribution of industry *i* to aggregate productivity growth because of a faster (or slower) productivity growth in country A compared to country B, i.e. the "productivity growth effect" (ΔP)
- The difference between the first term of (4) and the first term of (2) shows the difference in contribution of industry *i* to aggregate productivity growth because of a higher (or lower) employment share of industry *i* in country A compared to country B, i.e. the "employment share effect" ($\overline{S}$).
- The difference between the second term of (4) and the second term of (2') reflects the difference in contribution of industry *i* to aggregate productivity growth because of a higher (or lower) productivity level in country A compared to country B relative to the aggregate productivity level, i.e. the "productivity level effect" ($\overline{P}$).
- The difference between the second term of (4) and the second term of (2) reflects the difference in contribution of industry *i* to aggregate productivity growth because of a faster rise (or slower fall) in the employment share of industry *i* in country A compared to country B, i.e. the "change in employment share effect" (ΔS).

Next we can also impose country A's employment structure on country B, which transforms equation (2') into:

$$\frac{\Delta P^{B|A}}{P_t^B} = \sum_{i=1}^{n} \frac{\Delta P_i^B \overline{S}_i^A}{P_t^B} + \sum_{i=1}^{n} \frac{\Delta S_i^A \overline{P}_i^B}{P_t^B} \qquad (4')$$

This second counterfactual results in the same four effects described above, but will obviously give a different result because we now assume country A's employment structure instead of that of country B. As there is no *a priori* reason to prefer one or the other employment structure for the counterfactual, we take a simple unweighted average of each of the four effects based on country A's or country B's structure.

To gain a fuller understanding of the procedure, we illustrate this decomposition with an example. For the period 1995-2000, productivity growth in the computer industry (ISIC 30) was 49.3 percent per year in the EU, compared to 52.3 percent in the U.S. On average the industry was responsible for only 0.14 percent of total employment in the EU and 0.18 percent in the United States, and the employment share went down by 0.03 percentage points in the EU and by 0.05 percentage points in the U.S. between 1995 and 2000. To trace the effects of these differences on the industry's contribution to the aggregate productivity growth differential between the U.S. and the EU we run the counterfactuals as in equations (4) and (4').

The matrix in Table 2 shows the within-effects for both countries under both sets of employment shares as well as the differences between the U.S. and EU. Taking the U.S. as country A (and the EU as country B) suggests that the computer industry in the U.S. has a within-effect contribution to aggregate productivity growth of 0.274 percentage-point (according to the first term of equation (2)), which would have been 0.199 percent in case the U.S. had the same employment structure as the European Union (according to the first term of equation (4)). Hence the U.S.-EU productivity differential is 0.075 percentage points due to a bigger share of the U.S. computer industry in total employment ($\bar{S}$). This difference would have been 0.053 percentage points had we looked at the EU within-effects, as is shown in the second column of Table 2 (comparing the first terms of equations (2') and (4')). If we compare across the columns instead of across the rows in Table 2, we find that the contribution to the U.S.-EU productivity growth differential due to faster productivity growth in the U.S. computer industry (ΔP) is 0.066 percentage points when imposing the U.S. employment structure on both the U.S. and the EU (comparing the first terms of equations (2) and (4')). It becomes 0.045 when assuming the EU employment structure for both the U.S. and the EU (comparing the first terms of equations (2') and (4)).

Overall the within-effect contributed 0.120 percentage points (0.274-0.154) to the aggregate U.S.-EU productivity differential. A straightforward way to calculate the average productivity growth effect is then to take an unweighted average of the two figures in the last column of Table 2 which comes to 0.056 percent. The remainder of the difference in within-effect is then due to differences in industry size. This is equal to the average of the figures in the row "Difference due to different employment shares" or 0.064 percent. Together, these two effects exactly add up to the total difference in intra-effect of 0.120 percentage points.

We can then run a similar analysis which focuses on the second terms of equations (2), (2') and (4) and (4'), the "shift or "in between" effect, for the computer industry. The four possible comparisons between these second terms lead to another matrix (Table 3), that shows contributions to the productivity growth differential because of differences in (relative) productivity levels ($\overline{P}$) or because of differences in the change in employment shares (ΔS).

Table 3 shows that in the case of the computer industry the between-effects are always negative. This is a consequence of the declining employment share of the computer industry in both Europe and the United States. The bottom row and right hand columns in the Table also show that the U.S. between-effect is more strongly negative than in Europe due to both a larger decline in employment share in (–0.011 and –0.008) and a higher productivity level relative to the aggregate productivity level for the U.S. economy (–0.007 and –0.004).[15]

6. Differences between Europe and the U.S.

Table 4 shows the results of the decomposition from the previous Section for the 7 industry groups from Table 1. The first two columns show the contribution of each industry group to aggregate productivity growth in the EU and the U.S. respectively. The third column is the difference between the two. This column confirms the main differences identified before. Together, ICT producing manufacturing and ICT using services account for more than the total productivity growth difference between the EU and the U.S. because there are offsetting effects, mainly in ICT producing services and the non-ICT industries. The remaining columns in Table 4 decompose this difference into the four factors discussed above. It shows that in ICT producing manufacturing the difference in contribution is mainly a case of differences in employment shares in the EU and the U.S. This point was already hinted at in the value added shares from Table 1. ICT producing manufacturing makes up 2.6 percent of U.S. GDP versus 1.6 percent of EU GDP. However, within this industry there are important differences as well. The computer industry is only 0.23 percent of EU GDP but 0.35 percent of U.S. GDP. In semiconductors, the difference is even bigger: 0.24 in the EU versus 0.79 percent in the U.S.. Since these two industries have shown productivity growth rates in excess of 50 percent per year on average after 1995, these differences have a large effect on aggregate outcomes.

The largest contributor to the overall productivity growth difference is the ICT using services sector. In this sector, much higher productivity growth rates in U.S. ICT using services explain most of the productivity growth differential. Figure 1 gives a more detailed overview of the differences by showing the total difference in contribution for each of the 10 ICT services (including ICT producing services). The Figure shows the difference in contribution between each industry in the U.S. and in the EU. The first term within brackets refers to the productivity growth effect and the second to the sum of the other three effects. Figure 1 shows that only three industries account for the difference in productivity growth contribution, namely wholesale and retail trade and securities trade. Together, these industries account for 0.9 of the 1.1 percentage point growth differential between the EU and the U.S.. The first number between brackets also makes clear that especially in the trade industries, higher U.S. productivity growth is by far the most important factor. In securities trade, the higher U.S. employment share also plays a considerable role. At the other end of the scale, the ICT producing services, telecommunications and computer services, make larger contributions to growth in Europe than in the United States. Here too, productivity growth is the most important factor, although it is partly offset by a faster increase in the employment share of these industries in the U.S.[16]

Employment share changes are much less important mainly because, at the level of 51 industries, the level of aggregation is still too high to pick up any substantial differences in changes in employment shares and also because we study only a fairly short period of time (1995-2000). Even for the longer period of 1990 to 2000, the effect is relatively small. In other words, for structural change in the sense of employment shifts between industries, longer periods have to be studied or more detailed data. But still, for a few industry groups the effect of changing employment shares is far from negligible. In non-ICT services and other non-ICT industries, employment share changes even make the largest contribution to the difference between the U.S. and the EU. In non-ICT services, the employment share of real estate rises for the EU, but stays constant in the United States. The big impact is striking as the increase in the employment share is only small, from 0.96 percent to 1.03 percent of total employment. The reason for the sizeable effect is that in both Europe and the U.S. real estate has a very high labour productivity level, as it includes the (rental) value of residential housing services.[17] From the standpoint of our decomposition, this means any changes in the importance of this industry (as measured by its employment share) gets a very large weight because of the high relative productivity level of this industry.

In other non-ICT industries, larger changes in employment shares can be observed. The most important of these is a large increase in the employment share of the U.S. construction industry from 5.1 to 5.7 percent of total employment, while this industry showed a decline from 7.3 to 6.9 percent in Europe. In the U.S., this increase accounted for 12 percent of total employment growth,

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[15] The higher productivity level relative to the aggregate productivity level gives a larger weight to the decline in employment share.
[16] See Appendix Table A1 for a full list of the industry contributions and the decomposition.
[17] The reason for this is to preserve the national accounting identities, while these are not specific services provided by real estate agents.

the second largest contribution after that "other business services". Finally, in ICT using services, we can observe that professional services have grown much faster in Europe than in the United States. Between 1995 and 2000, the employment share of this industry increased from 3.6 to 4.2 percent, while in the U.S., it increased only from 3.1 to 3.4 percent.

Also interesting is that the productivity level effect is negligible in most industries. In the majority of industries, this effect is rounded to 0.00 in Table A1. This means the industry productivity levels relative to the aggregate productivity level are very comparable across Europe and the United States.[18] This is confirmed by the correlation between those ratios for the EU and the U.S., which is very high at 0.93.[19] The implications of this finding are not immediately clear, however. Both the characteristics of employment growth and the similarities between productivity levels in Europe and the U.S. look to be interesting avenues for further research.

7. *Conclusions*

With a spreading consensus that growth in the United States has benefited from the adoption of ICT, more evidence becomes available that Europe is clearly lagging in this respect. Most European economies show considerably lower investment level in ICT goods than the U.S.. Furthermore, as productivity growth in the U.S. accelerated, European productivity growth slowed down since the mid 1990s. The main contribution of this study is a quantification of the sources of the differences at the industry level.

Productivity growth in industries like wholesale and retail trade and securities trade was very high in the U.S. during the second half of the 1990s, while European growth in these industries was modest by comparison. In this paper we have used a modification of the traditional shift-share techniques to show that these three industries are responsible for a large part of the aggregate growth differential between Europe and the United States. While the larger employment shares of ICT producing industries, like computers and semiconductors also play an important role, it is the ICT using services which account for the largest part of the differences.

This raises the question why these industries would show much faster growth in the U.S. than in Europe. It is unlikely to be a matter of insufficient access to new technologies, as the market for ICT goods is essentially global. Also, the strong performance of telecommunications in Europe suggest there are certainly opportunities to benefit from new technologies like wireless

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[18] This is not a general feature of this type of decomposition, see for example van Ark, Inklaar and Sleifer (2002).

[19] The outlying productivity level of real estate has no major influence on this. Without that industry, the correlation would be 0.81 and the rank correlation is 0.86.

telephony in Europe too. Furthermore the growth of ICT investment has been large in Europe as well.

McGuckin and van Ark (2001) argue that structural impediments in product and labour markets hamper the successful implementation of ICT in Europe. Limits on shopping hours and transport regulations and restrictive hiring and firing rules as well as other restrictive labour regulations make it hard for producers to organize their organizations to reap the full benefits from ICT. Furthermore, barriers to entry also limit competitive pressure. Recent research for U.S. retail trade has shown that entry of productive new firms and exit of low-productive firms is responsible for almost all of labour productivity growth in this sector (see Foster, *et al.*, 2002). However, we are careful not to embrace the simple story of excessive European regulation. The more rapid take-off of wireless technology in Europe suggests that some regulation regarding for example standards might be very beneficial. Still, the question why most European economies have been unable to combine employment and productivity growth should remain high on the research agenda.

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Table 1: Productivity growth and GDP shares of ICT producing, ICT using and non-ICT industries in the EU and the U.S.

	Productivity growth				GDP share	
	1990-1995		1995-2000		2000	
	EU[b]	US	EU[b]	US	EU[b]	US
Total Economy	1.9	1.1	1.4	2.5	100.0	100.0
ICT Producing Industries	6.7	8.1	8.7	10.1	5.9	7.3
ICT Producing Manufacturing	11.1	15.1	13.8	23.7	1.6	2.6
ICT Producing Services	4.4	3.1	6.5	1.8	4.3	4.7
ICT Using Industries[a]	1.7	1.5	1.6	4.7	27.0	30.6
ICT Using Manufacturing	3.1	-0.3	2.1	1.2	5.9	4.3
ICT Using Services	1.1	1.9	1.4	5.4	21.1	26.3
Non-ICT Industries	1.6	0.2	0.7	0.5	67.1	62.1
Non-ICT Manufacturing	3.8	3.0	1.5	1.4	11.9	9.3
Non-ICT Services	0.6	-0.4	0.2	0.4	44.7	43.0
Non-ICT Other	2.7	0.7	1.9	0.6	10.5	9.8
Pro memoria: with national deflators						
Total Economy	1.9	1.1	1.4	2.5		
ICT Producing Manufacturing	7.8	15.1	10.1	23.7		

a) excluding ICT producing
b) EU includes Austria, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden and the United Kingdom, which represents over 90% of EU GDP.
Notes: Productivity is defined as value added per person employed
Source: van Ark *et al*. (2002a)

Table 2, Intra-effects for the computer industry (ISIC 30) in the U.S. and the EU with different employment structure, 1995-2000 (%-point contributions)

Intra-effect	U.S.	EU	Difference due to different productivity growth
U.S. shares	0.274	0.207	0.066
EU shares	0.199	0.154	0.045
Difference due to different employment structure	0.075	0.053	

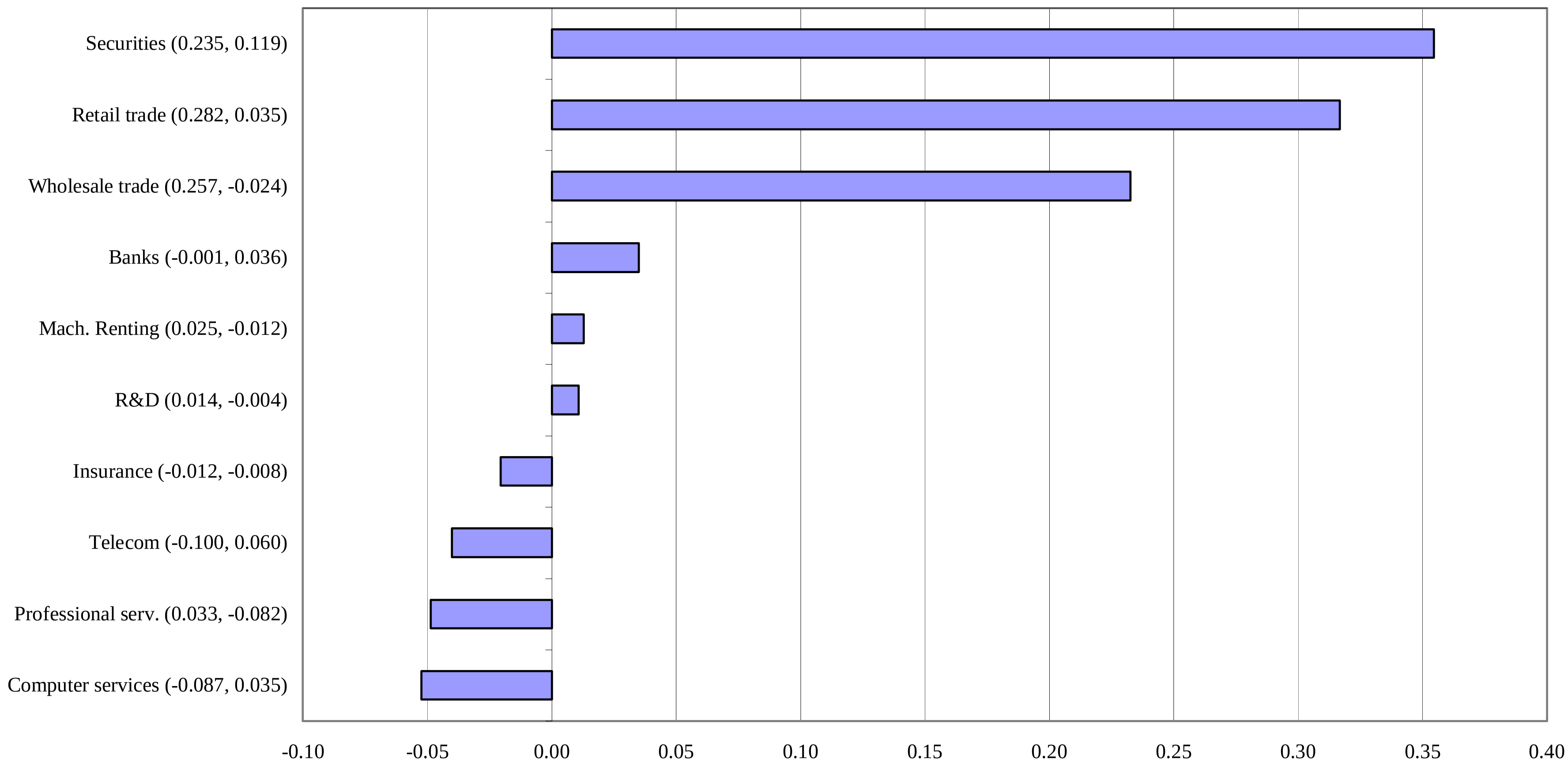
Table 3, Shift-effects for the computer industry (ISIC rev. 30) in the U.S and the EU with different employment structure, 1995-2000 (%-point contributions)

Shift-effect	U.S.	EU	Difference due to different productivity levels
U.S. shares	-0.029	-0.022	-0.007
EU shares	-0.017	-0.013	-0.004
Difference due to different change in employment structure	-0.011	-0.008	

Table 4: Contribution of industry groups to aggregate productivity growth and decomposition for the EU and U.S. for 1995-2000

	Contribution in productivity growth		Total difference	Contribution of			
	U.S.	EU	U.S.-EU	*Productivity Growth*	*Employment Share*	*Productivity Level*	*Change share Employment*
Total Economy	2.49	1.40	1.09	0.84	0.35	-0.08	-0.02
ICT Producing Industries	0.99	0.60	0.39	0.00	0.29	-0.01	0.11
ICT Producing Manufacturing	0.73	0.25	0.48	0.18	0.29	0.00	0.01
ICT Producing Services	0.26	0.35	-0.09	-0.19	0.01	-0.01	0.10
ICT Using Industries[a]	1.22	0.42	0.80	0.77	0.13	0.03	-0.12
ICT Using Manufacturing	-0.08	0.01	-0.09	-0.06	-0.01	0.00	-0.02
ICT Using Services	1.30	0.41	0.89	0.83	0.14	0.02	-0.11
Non-ICT Industries	0.28	0.38	-0.10	0.07	-0.08	-0.09	-0.01
Non-ICT Manufacturing	-0.05	0.04	-0.09	-0.01	-0.05	-0.02	-0.01
Non-ICT Services	0.23	0.38	-0.14	0.13	0.04	-0.07	-0.25
Non-ICT Other	0.10	-0.03	0.13	-0.05	-0.07	0.00	0.25

Figure 1, Contribution of ICT producing and ICT using services to the U.S.-EU productivity growth differential, 1995-2000



Legend:
Industry (productivity growth effect, other effects)

Appendix Table A1: Contribution of industries to total labor productivity growth for 1995-2000 for the EU and U.S. and the decomposition into four effects

		U.S.	EU	Difference	*Productivity growth*	*Employment share*	*Productivity level*	*Emp. share change*
Total Economy		**2.49**	**1.40**	**1.09**	**0.84**	**0.35**	**-0.08**	**-0.02**
Total ICT producing manufacturing		**0.73**	**0.25**	**0.48**	**0.18**	**0.29**	**0.00**	**0.01**
30	Office and Comp. Eq.	0.24	0.14	0.10	0.06	0.06	-0.01	-0.01
313	Fiber optics	0.00	0.00	0.00	0.00	0.01	0.00	-0.01
321	Semiconductors	0.50	0.14	0.36	0.13	0.21	0.00	0.02
322	Communication eq.	0.02	0.02	0.00	-0.01	0.00	0.00	0.01
323	Radio and TV eq.	0.00	-0.02	0.01	0.00	0.01	0.00	0.00
331	Instruments	-0.03	-0.03	0.00	0.00	0.00	0.00	0.00
Total ICT producing services		**0.26**	**0.35**	**-0.09**	**-0.19**	**0.01**	**-0.01**	**0.10**
64	Telecommunications	0.16	0.20	-0.04	-0.10	0.01	0.00	0.05
72	Computer services	0.09	0.14	-0.05	-0.09	0.00	-0.01	0.05
Total ICT using manufacturing		**-0.08**	**0.01**	**-0.09**	**-0.06**	**-0.01**	**0.00**	**-0.02**
18	Apparel	-0.02	-0.01	0.00	0.00	0.00	0.00	0.00
22	Printing & Publishing	-0.03	0.00	-0.03	-0.03	0.00	0.00	0.00
29	Machinery	-0.02	0.00	-0.02	-0.01	0.00	0.00	0.00
31-31.3	Electrical machinery	-0.01	0.01	-0.02	-0.02	0.00	0.00	0.00
33-33.1	Watches & instruments	0.00	0.00	-0.01	0.02	-0.01	0.00	-0.01
35.1	Ships	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
35.3	Aircraft	-0.01	0.00	-0.01	-0.02	0.01	0.00	0.00
35.2+35.9	Railroad and other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36-37	Misc. manufacturing	0.01	0.00	0.01	0.01	0.00	0.00	0.01
Total ICT using services		**1.30**	**0.41**	**0.89**	**0.83**	**0.14**	**0.02**	**-0.11**
51	Wholesale trade	0.30	0.07	0.23	0.26	0.02	0.00	-0.04
52	Retail trade	0.38	0.06	0.32	0.28	0.05	0.00	-0.02
65	Banks	0.10	0.06	0.04	0.00	0.00	0.00	0.04
66	Insurance	-0.03	-0.01	-0.02	-0.01	0.00	0.00	-0.01
67	Securities trade	0.37	0.02	0.35	0.24	0.08	0.02	0.02
71	Renting of machinery	0.04	0.03	0.01	0.03	0.00	-0.01	0.00
73	R&D	0.01	0.00	0.01	0.01	0.00	0.00	0.00
74.1-74.3	Professional services	0.11	0.16	-0.05	0.03	-0.01	0.02	-0.10
Total Non-ICT manufacturing		**-0.05**	**0.04**	**-0.09**	**-0.01**	**-0.05**	**-0.02**	**-0.01**
15-16	Food products	-0.09	-0.02	-0.07	-0.09	0.03	0.00	0.00
17	Textiles	-0.01	-0.01	0.00	0.01	0.00	0.00	-0.01
19	Leather	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
20	Wood products	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00
21	Paper products	-0.01	0.00	-0.02	-0.01	0.00	0.00	-0.01
23	Petroleum & coke	0.00	-0.01	0.01	0.01	0.00	0.00	0.00
24	Chemicals	0.04	0.05	-0.01	0.03	-0.04	-0.02	0.02
25	Rubber and plastics	0.02	0.01	0.00	0.02	0.00	0.00	-0.01
26	Stone, clay & glass	0.01	0.00	0.01	0.01	-0.01	0.00	0.01
27	Basic metals	0.01	-0.01	0.02	0.01	0.00	0.00	0.01
28	Fabricated metal products	0.00	0.01	-0.01	0.00	-0.01	0.00	0.00
34	Motor vehicles	0.01	0.03	-0.02	0.01	-0.01	0.00	-0.03
Total Non-ICT services		**0.23**	**0.38**	**-0.14**	**0.13**	**0.04**	**-0.07**	**-0.25**
50	Repairs	-0.02	0.03	-0.05	-0.05	0.00	0.00	-0.01
55	Hotels & restaurants	0.01	0.02	-0.01	0.05	-0.01	-0.01	-0.04
60-63	Transportation	0.07	0.09	-0.02	-0.01	-0.02	0.00	0.01
70	Real estate	0.14	0.05	0.09	0.23	0.01	-0.02	-0.13
74.9	Other business services	0.14	0.12	0.02	0.04	0.00	-0.03	0.00
75	Government	-0.09	-0.03	-0.06	-0.07	0.04	0.00	-0.02
80	Education	0.00	-0.01	0.01	-0.02	0.01	0.00	0.02
85	Health	-0.01	0.05	-0.06	-0.04	0.00	0.00	-0.02
90-93	Personal & social services	-0.01	0.05	-0.06	0.00	0.00	-0.01	-0.05
Total Non-ICT other industries		**0.10**	**-0.03**	**0.13**	**-0.05**	**-0.07**	**0.00**	**0.25**
01-05	Agriculture	0.06	0.01	0.05	0.05	-0.06	-0.01	0.06
10-14	Mining	-0.05	-0.02	-0.03	-0.05	0.00	0.01	0.00
40-41	Utilities	-0.02	0.02	-0.04	-0.05	-0.01	-0.01	0.03
45	Construction	0.11	-0.05	0.16	0.00	0.00	0.00	0.16