New technologies and productivity in the euro area

This article provides an overview of the currently available evidence on the importance of information and communication technologies (ICT) for developments in productivity growth in the euro area. On the basis of the available data, there is evidence of an increased contribution of ICT to economic growth both in terms of production and investment in the second half of the 1990s. However, there is – as yet – little if any evidence of positive spillover effects from the use of ICT to overall productivity growth. As to this latter conclusion, it is important to note that further structural reforms are crucial in order to reap the full benefits of the new technological possibilities. In itself, the increased contribution of ICT to productivity growth, however, implies that uncertainties surrounding the estimates of potential output growth have become skewed to the upside.

1 Introduction

This article focuses on the contribution of information and communication technologies (ICT) to the growth rate of productivity in the euro area. From a macroeconomic perspective, a sustained increase in productivity growth owing to ICT is generally considered the most important aspect of a "New Economy". In this respect, a distinction is often made between a sustained increase in productivity growth resulting from developments in the ICT producing sectors and increases in productivity growth in the economy as a whole caused by the spreading use of ICT. The rapid productivity increase witnessed in the production of ICT is of interest on its own, but is in itself not sufficient to define a "New Economy" characterised by an economy-wide increase in productivity growth. For that, it would be necessary that ICT have the character of a so-called general purpose technology, i.e. that the use of ICT would cause a more rapid increase in the overall efficiency of the economic process. This would imply that the economy has reached a higher rate of growth of potential output.

Productivity growth is most often measured in terms of labour productivity, i.e. as the increase in output per person employed or, preferably, in output per hour worked. Growth in labour productivity can be the result of an increase in the amount of capital available per hour worked (capital deepening) or of an increase in the overall efficiency of the economic process, as measured by gains in total factor productivity (TFP). An acceleration in labour productivity growth owing to an increase in TFP growth would be a sign of a "New Economy". However, as opposed to labour productivity, TFP growth cannot be measured directly and is difficult to estimate in practice. This article first discusses developments in labour productivity, before giving some estimates of developments in TFP growth in the euro area. On account of data constraints, this article mainly focuses on developments in the 1990s.

The impact of a technological change always depends on the quality of the accompanying policies and on a number of other factors. These policies and factors include the liberalisation of domestic financial markets and the progressive international integration of these markets; the availability of risk capital to innovative firms combined with sound management; the globalisation of trade in goods and services and increased product market competition; more labour market flexibility; a monetary policy ensuring price stability; and a fiscal policy which reduces debt and tax burdens, leaving room for private investment. Although these policies and other factors are not the focal point of this article, they should nevertheless be kept in mind when assessing the importance of ICT for economic growth. Only by meeting all conditions will it be possible to reap the full benefits of what the new technologies have to offer.

2 Labour productivity in the euro area and the United States

In the 1990s, growth of real GDP was on average higher in the United States than in the euro area. Table 1 presents a decomposition of the growth of GDP per capita. Demographic changes, (a), changes in labour force participation, (b), and changes in the employment rate, (c), account for differences between the growth rates of GDP per capita and of GDP per person employed. Likewise, changes in the number of working hours, (d), explain the differences between the growth rates of GDP per person employed and of GDP per hour worked. The table thus highlights that the observed difference in GDP growth per capita between the United States and the euro area is attributable to different developments in labour utilisation and not to a difference in labour productivity growth.

Chart 1 presents developments in labour productivity and employment, both measured in total hours worked, in the euro area and the United States over a somewhat longer time horizon. Labour productivity is usually calculated either in terms of output per person employed or output per hour worked. The latter measure is generally considered the more appropriate one since the development of output per person employed is influenced also by the average number of hours worked. Given the increasing importance of part-time work, the use of output per person employed would lead to a downward bias of productivity figures in the euro area in particular.

Chart 1 shows that labour productivity growth in the United States displayed no

Table 1

Decomposition of annual growth in GDP per capita, 1990-2000

(percentages and percentage points)

	GDP per capita	Working age population/ total population	Labour force participation rate	Employment/ labour force	GDP per person employed	Average hours worked	GDP per hour worked
		(a)	(b)	(c)		(d)	
Euro area	1.8	-0.04	0.32	0.01	1.5	-0.37	1.8
United States	2.2	0.03	0.34	0.12	1.7	0.03	1.7

Source: ECB calculations based on data from the European Commission and the OECD.
Note: Figures may not add up due to rounding.

Chart 1

Labour productivity and employment growth, 1981-2000

(annual percentage change in real GDP per hour worked and in total hours worked)

Source: ECB calculations based on data from the European Commission and the OECD.

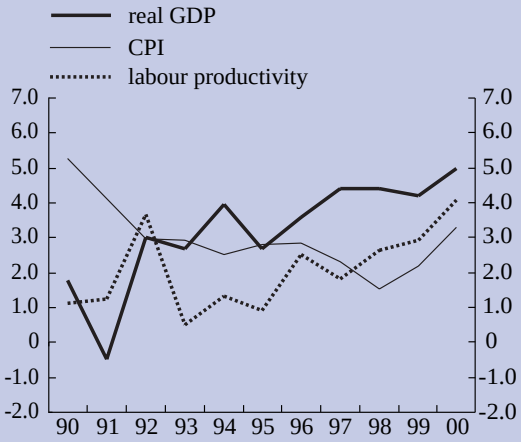
Box 1

United States: recent developments in labour productivity and private business investment

In the United States, the rise in labour productivity growth in the non-farm business sector during the second half of the 1990s is considered to be the main explanation for the combination of rapid output growth with subdued inflation during that period (see Chart A). However, a consensus view has not yet emerged about the source of the productivity growth and, by extension, about whether the recent productivity gains are mostly a cyclical phenomenon or, instead, have more permanent implications. A large majority of studies argue that capital accumulation, especially through investment in computer hardware and software, has been the driving force behind labour productivity growth (the "capital deepening" explanation). Furthermore, this surge in labour productivity is seen mostly as a cyclical phenomenon. More recently, however, some studies have argued that technical progress has been the main source of output growth (the "total factor productivity" explanation), with a sizeable impact on the long-run rate of productivity growth, i.e. on trend productivity growth.

Chart A: Real GDP, output per hour (non-farm business sector) and the Consumer Price Index (CPI) in the United States

(annual percentage change)



Empirical work in this area has been polarised by Robert Gordon's contributions – highlighting capital deepening factors with a small effect on trend productivity – and by Stephen Oliner and Daniel Sichel's work – supporting the idea of a larger effect on trend productivity growth.[1] Gordon estimates the increase in trend productivity growth in the period from 1996 to 1999 from the period from 1972 to 1995 to be only 0.62 percentage point, with half of this increase explained by capital deepening and the remaining half by a rise in total factor productivity, concentrated only in the durable goods producing sector. On the other hand, Oliner and Sichel estimate labour productivity growth in the period from 1996 to 1999 to be 1.05 percentage points higher than over the period from 1990 to 1995. Most of this difference is explained by deepening in information and communication technologies (ICT) capital, while the remainder is explained by the increase in total factor productivity – both in the ICT sector and in the rest of the non-farm business sector. At the root of the difference in results between the two studies lies the different methodological approach employed to decompose productivity growth into the contributions of capital, labour and the "residual" (total factor productivity). In a series of recent studies, Nordhaus provides evidence confirming Oliner and Sichel's results, showing that productivity growth in the business sector in the period from 1996 to 1998 accelerated to 3.2%, up from 1.3% in the period from 1978 to 1995, and that about one third of the productivity acceleration comes from non-ICT producing sectors.[2]

Against this background, it is safe to argue that while the contribution of total factor productivity remains uncertain, the sharp rise in investment, especially in ICT capital goods, that occurred in the United States since 1992 has certainly increased the rate of productivity growth of the economy as a whole. In this context, the issue remains whether such high growth rates of investment, especially in the ICT sector, are sustainable or not.

1 *Oliner, S. D. and Sichel, D. E., "The resurgence of growth in the late 1990s: is information technology the story?" and Gordon, R. J., "Does the "New Economy" measure up to the great inventions of the past?", both published in the Journal of Economic Perspectives, Vol. 14, Fall 2000.*

2 *See, among others, "Productivity growth and the New Economy" (NBER WP 8096), January 2001.*

Labour productivity growth and contributions

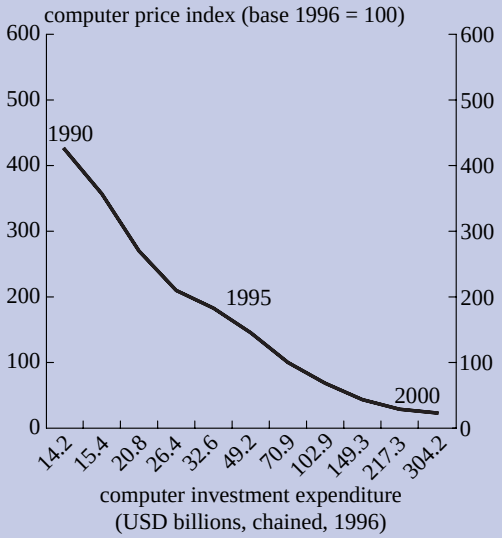
(average annual percentage growth rates, difference between selected periods)

	Labour productivity (interval)	*Of which capital deepening*	*Of which TFP*	*Of which price measurement*	*Of which labour quality*
Oliner-Sichel	1.05 (1996-99 vs. 1991-95)	0.49	0.68	-	-0.13
Gordon	0.81[1)] (1995-99 vs. 1972-95)	0.33	0.29	0.14	0.05
Nordhaus	1.9 (1996-98 vs. 1978-95)	-	-	-	-

1) Figures refer to "trend" productivity growth.

In this regard, a critical aspect is whether the declining trend of computer prices – both in absolute and relative terms – will come to a halt in the years ahead. Indeed, during the last decade, declining computer prices resulted in a demand shift from "traditional" goods to ICT capital goods and have therefore been associated with the overall increase in investment expenditure on ICT capital goods (illustrated by Chart B). In the context of historically diminishing returns for investment in ICT capital goods, further decreases in computer prices appear therefore to be a prerequisite for the sustained growth of computer investment and, consequently, of total investment.

Chart B: Private business investment – the demand schedule for computer capital goods, 1990-2000



Future developments of investment spending on ICT capital goods will shed light on the extent to which computer technology has really founded a "New Economy". Confirmation of such a structural shift in the US economy's production possibility frontier would be provided by a continuation of growth in ICT capital goods even in the absence of further computer price declines (i.e. the demand curve in Chart B shifts to the right).

particular trend up to the mid-1990s. Thereafter, in the period up to and including 2000, labour productivity growth clearly accelerated. While the rate of productivity growth attained in that period is in itself not without precedent, the acceleration has, in contrast to the past, been achieved with steady employment growth. Moreover, the acceleration of labour productivity growth in the United States has been accompanied by an increase in investment growth, to a large extent driven by strong ICT investment (see also Box 1 "United States: recent developments in labour productivity and private business investment"). This clear break with past experiences would suggest that the US economy has developed new characteristics.

Developments in the euro area have been different. Labour productivity has on average grown at a relatively high, though slightly downward trending, rate. Over longer periods, this relatively high rate of productivity growth has been accompanied by adverse developments in total hours worked, in

particular in the first halves of the 1980s and the 1990s. However, in the second half of the 1990s employment growth accelerated again. As yet, this has not been accompanied by a clear change in labour productivity developments.

3 The importance of ICT for the euro area

Several recent studies concluded that ICT have played an increasing role in explaining economic growth in the euro area in recent years. A study by the European Commission, for example, presented a number of scenarios, the most optimistic of which suggests that Europe would at present be lagging the United States by only approximately five years in terms of experiencing the impact of ICT on economic growth.[1] It thus seems warranted to further investigate the contribution of ICT to economic growth in the euro area, as a driving force behind a possible acceleration in productivity over a longer term horizon.

3.1 Sectoral developments

To assess the importance of ICT for economic developments in the euro area, this section considers developments in economic growth at the sectoral level, in the ICT sector in particular. The ICT sector has been broken down into ICT producing and ICT using sectors (see Table 2).[2] This last distinction is of interest, because any positive spillover effects from the use of ICT should become apparent in sectors other than the ICT producing sectors themselves. The ICT using sectors are defined as having a relatively high ratio of ICT investment to industry output and a relatively high share of the overall ICT capital stock. Other sectors use ICT as well, and indeed it could be argued that even a limited use of ICT might make for a clear improvement in the production process. The ICT using sectors distinguished here might thus be seen as only a rough measure of the importance of ICT use.

Data on gross value added and employment at a detailed sectoral level were available for four euro area countries: Germany, France, Italy and Finland (accounting for around 73% of euro area nominal gross value added). The

1 *European Commission, "The EU Economy 2000 Review", November 2000.*

2 *The classification of ICT producing industries closely follows that of the OECD. The classification of ICT using industries closely follows the classification made in Van Ark, B., "The Renewal of the Old Economy: Europe in an Internationally Comparative Perspective", update of English translation of a paper for Preadviezen 2000 of the Netherlands Royal Economic Society, March 2001.*

Table 2

Classification of ICT producing and using industries

ICT producing sector, manufacturing:
Office, accounting and computing machinery (code 30) and radio, television and communication equipment (code 32).

ICT producing sector, services:
Post and telecommunications (code 64) and computer and related activities (code 72).

ICT using sector, manufacturing:
Chemicals and chemical products (code 24), electrical machinery and apparatus, not elsewhere classified (code 31), and medical, precision and optical instruments (code 33).

ICT using sector, services:
Financial intermediation (code 65), insurance and pension funding (code 66), activities related to financial intermediation (code 67), renting of machinery and equipment (code 71), research and development (code 73), and "other business activities" (code 74).

Note: Codes in brackets are from the international standard industry classification, revision 3. Only about half of the category "other business services" qualifies as ICT using. Therefore, a 50% split was applied to this category.

Table 3

Sectoral developments in the euro area [1)]

	Share in nominal value added		Growth in real value added		Growth in employment		Growth in labour productivity	
	1991 %	1998 %	1991-98 %	1995-98 %	1991-98 %	1995-98 %	1991-98 %	1995-98 %
ICT producing sectors, manufacturing	0.9	0.7	6.5	11.5	-5.6	-2.3	12.9	14.2
ICT producing sectors, services	3.6	4.2	5.5	8.1	-0.5	0.1	6.1	7.9
ICT using sectors, manufacturing	4.5	3.9	0.8	1.6	-3.0	-1.1	3.9	2.7
ICT using sectors, services	11.3	12.0	2.4	3.2	2.2	2.9	0.2	0.3
Manufacturing	21.0	18.6	0.7	1.5	-2.5	-0.6	3.3	2.1
Business services	47.9	51.8	2.2	2.7	1.0	1.8	1.2	0.9
Total economy	100	100	1.5	1.9	-0.3	0.4	1.8	1.4

Source: ECB calculations based on data from the OECD STAN database.
Note: Owing to the rapid decline of measured prices in the ICT producing manufacturing sector, its share in nominal value added decreased, despite high rates of growth in real value added. Manufacturing and business services include the ICT sectors.
1) Euro area estimate based on Germany, France, Italy and Finland, which together account for around 73% of euro area nominal gross value added.

data from these four countries were used to calculate a euro area estimate for gross value added and employment (in persons) by sector.[3] Unfortunately, data for all four countries are available only for the years 1991 through 1998.

Table 3 shows that the ICT producing sectors, both in manufacturing and services, were by far the most dynamic sectors in the euro area in terms of growth rates of real value added and labour productivity, with a clear pick-up in growth rates of both variables in the second half of the 1990s. However, the size of these sectors is relatively small, at less than 5% of total nominal value added. This implies that their impact on developments in economic activity in the euro area as a whole is limited, albeit noticeable, as they do account for about one sixth (0.3 percentage point) of total euro area labour productivity growth over the years 1991-1998. As for the ICT using sectors, there has been no clear increase in the growth rates of real value added or labour productivity. In the ICT using services sector, measured labour productivity growth has even been close to zero. This is also the sector with the highest employment growth, reaching almost 3% annually in the second half of the 1990s. Indeed, the ICT using manufacturing sector and the ICT producing sectors had zero or even negative employment growth. Lastly, the absence of stronger dynamics in the ICT using sectors than on average in the manufacturing and the business services sectors suggests that, over the period examined, positive spillover effects from the use of ICT have only been limited if present at all.

In comparing these results with those of the United States (see Table 4), four points come to the fore.[4] First, the growth rates in labour productivity of the ICT producing sectors in

3 *The euro area economic structure may differ from the euro area estimate presented here, which is based on only a sub-set of countries. Furthermore, the aggregation of gross value added is not fully harmonised across euro area countries, as use is made of both chain-weighted and fixed-weight aggregates. Moreover, considerably different price indicators are used, including hedonic deflators. However, here (and in the following sub-section), these factors are not taken into consideration. All this implies that there is a bias in the euro area estimate as presented here, the precise size and direction of which are however unknown.*

4 *Due consideration should be given to the fact that the results may be influenced by differences in cyclical positions, in particular for the shorter time period shown (1995-98).*

the euro area seem comparable to those in the United States, at 14.2% and 21.3% respectively in the second half of the 1990s, especially since part of the measured difference may be related to statistical problems. The hedonic method used in the United States to separate price and quality changes produces lower price and higher output changes than the approaches used in most of the euro area, where only France uses the hedonic approach (see also Box 2 "Measurement problems related to productivity"). For the period from 1995 to 1998, for example, the average annual decline in the implicit value added deflator for the ICT producing manufacturing sector amounted to 7.1% in the euro area and 12.5% in the United States. The difference of 5.4 percentage points is close to the difference in measured labour productivity growth. Second, in the United States, high productivity growth rates went hand in hand with an above average increase in employment in the ICT producing sectors, which contrasts with employment developments in those sectors in the euro area over this period. This could point to barriers to the creation of firms, resulting for example from the regulatory framework or the relative dearth of venture capital, or to a lack of human capital in these sectors in the euro area. Third, the share of the ICT producing manufacturing sector in total nominal value added was, at 1.8% in 1998, more than twice as high as the corresponding share in the euro area. This implies that the impact of this most dynamic sector on economy-wide developments is clearly stronger in the United States than in the euro area. Moreover, the output share of all ICT sectors taken together clearly increased in the United States from 19.3% in the first half of the 1990s to 22.7% in the second half, whereas it was more or less stable in the euro area at 20.3% and 20.7% respectively. Fourth, as in the euro area, in the United States the dynamics of the ICT using sectors in terms of value added and labour productivity appear not to be particularly strong when compared with the benchmark sectors (total manufacturing and total business services). This suggests that also in the United States there is little evidence of positive spillover effects from ICT producing sectors to the rest of the economy in the period from 1991 to 1998.

Overall, it can be concluded that output and labour productivity growth in ICT producing sectors in the euro area are clearly higher than in other sectors of the economy. This points to a positive impact of ICT on

Table 4

Sectoral developments in the United States

	Share in nominal value added		Growth in real value added		Growth in employment		Growth in labour productivity	
	1991 %	1998 %	1991-98 %	1995-98 %	1991-98 %	1995-98 %	1991-98 %	1995-98 %
ICT producing sectors, manufacturing	1.5	1.8	20.9	25.6	1.4	3.5	19.2	21.3
ICT producing sectors, services	4.0	4.8	6.3	7.8	3.9	5.3	2.3	2.4
ICT using sectors, manufacturing	3.4	3.0	2.4	2.9	-0.9	0.1	3.3	2.7
ICT using sectors, services	10.4	13.1	4.7	7.4	3.4	4.5	1.2	2.7
Manufacturing	17.4	16.4	4.5	4.1	0.3	0.6	4.2	3.5
Business services	48.3	52.7	4.8	6.6	2.6	2.9	2.2	3.7
Total economy	100	100	3.5	4.0	1.8	2.0	1.7	2.0

Source: ECB calculations based on data from the OECD STAN database.
Note: Owing to the rapid decline of measured prices in the ICT producing manufacturing sector, its share in nominal value added hardly increased, despite high rates of growth in real value added. Manufacturing and business services include the ICT sectors.

Box 2

Measurement problems related to productivity

The problem of measurement of macroeconomic data has featured prominently in recent discussions on the "New Economy". The techniques to account for quality changes in ICT production and expenditure in the national accounts have received particular attention. However, other measurement problems such as differences in methods to take account of changes in relative prices and problems related to measuring services sector output may be just as important in this regard. This box attempts to shed more light on these measurement issues.

It has been argued that, because conventionally constructed price indices do not fully capture quality improvements, price changes and hence volume changes may be distorted. In particular, it is sometimes argued that measured real GDP growth would be higher if prices of ICT goods were fully adjusted for quality improvements, for instance by using hedonic methods (i.e. a deflation technique based on a regression of the prices of a basket of goods on a set of qualities or characteristics of those goods, in order to identify price changes due to quality changes). However, the effects of such adjustments to ICT deflators would offset each other to some extent at the aggregate (GDP) level, even though disaggregated measures of input, output and expenditure could be affected substantially. Hence, in adjusting the deflation methods used, there is a need for a consistent approach.

This means that, viewed from the production side, hedonic deflators for ICT – or other appropriate adjustments for quality improvements – would have to be used on both the output and input sides. As ICT is often used as an input (intermediate consumption) in other sectors of the economy, input volumes in these sectors are likely to be higher if fuller account is taken of quality improvements, reducing value added in these sectors to the extent that real output is not affected. Consequently, measured productivity increases in the ICT using sectors would be lower. However, the opposite would be true for the ICT producing sectors, where value added would be higher. Viewed from the expenditure side, fuller allowance for quality improvements would not only raise real consumption and investment, but also entail corrections to imports and exports of ICT goods and services, which on balance would lower the contribution of net trade to economic growth for countries which are net importers of ICT. Thus, while the net impact on GDP of the use of hedonic deflators – or any other approach which appropriately adjusts for quality improvements – is likely to be positive, its exact size is difficult to assess a priori.

Furthermore, a consistent use of aggregation procedures to arrive at area-wide aggregates would be required as well. At present, several countries within the euro area use chain-type indices with annually changing weights in their national accounts to compute growth rates of real GDP and its components, as is done in the United States, while other euro area countries do not. Chain-type indices use adjacent period weights to allow for changes in relative prices and output over time. By contrast, some euro area countries use a fixed weight basis. The difference between the two methods is small as long as relative weights do not change significantly over time. However, in the event of significant changes in the relative weights, the use of a fixed basis leads to some distortion of the price and growth measurement, and this bias tends to increase with the distance from the base period. According to EU standards for national accounts (ESA 95), the use of annually chain-weighted measures is to be completed by 2005.

Apart from the issue of ICT deflators and aggregation procedures, there are other sources of measurement error which influence measured output and productivity. In particular, distinguishing between the price and quantity components of output has become increasingly difficult, as the share of services in total value added has increased over time. Identifying volume and price changes in the services sectors is difficult for a number of reasons. First, there is a relative dearth of primary statistics for the services sectors. Second, it is often conceptually more difficult to define the quantity of a particular service provided than the quantity of a

tangible good. In many cases, output of the services sectors is estimated on the basis of inputs, which implies a likely under-estimate of productivity growth. As the size of the services sectors has increased over time, it is likely that the measurement error has increased as well. For instance, in the euro area, the share of services (including government) in nominal value added increased from 56.9% in 1980 to 69.4% in 1999. The extent to which this will influence the international comparability of data is difficult to determine. In principle, any measurement problems associated with the increasing share of services in GDP would be common to all advanced economies. Nevertheless, the share of services may differ across countries. Moreover, and more generally, different accounting practices among statistical agencies could lead to a dissimilar impact. For instance, there are substantial differences in methodologies for distributing ICT expenditure between final and intermediate uses. Differences are observed, for example, in the recording of the business expenditure on software, for which the share that is allocated to investment is generally higher in the United States than in euro area countries.

In summary, differences in existing statistical practices between countries appear to hamper comparisons of output and productivity across countries and sectors. However, since the biases do not work systematically in one direction, the bias in aggregate output and productivity measures is expected to be smaller than the biases at the sectoral level. Thus, while measurement errors do cloud the picture, it seems unlikely that they are the major explanation for the lower recorded productivity growth in the euro area in recent years.

economic growth. However, the size of these sectors is still relatively small, implying that there has so far been only a limited impact on overall economic developments. Moreover, the fact that the growth rates of labour productivity in the ICT using sectors did not rise appreciably faster than in the non-ICT using sectors casts doubt, for the time being, on the existence of positive spillover effects from the use of ICT.

3.2 Contribution of new technologies to growth

To assess the relative importance of ICT for economic growth, a growth accounting exercise has been carried out (see Box 3 below). In particular, the contribution of ICT capital to output and labour productivity growth has been determined and estimates have been made of TFP growth (overall

Table 5

Decomposition of euro area output growth [1)]

	1991-95	1996-99	1991-95	1996-99
	absolute contribution to growth (percentage points)		relative contribution to growth (as a percentage of total)	
ICT capital	0.22	0.42	14	22
- *information equipment*	*0.09*	*0.15*	*6*	*8*
- *software*	*0.08*	*0.22*	*5*	*12*
- *communications equipment*	*0.05*	*0.05*	*3*	*3*
Other capital	0.56	0.47	37	24
Total hours worked	-0.66	0.43	-43	22
TFP	1.41	0.61	92	32
	annual average percentage growth			
Gross real value added	1.5	1.9	100	100

Source: ECB calculations based on data from the OECD and national accounts.

1) Euro area estimate based on France, Germany, Italy and the Netherlands, which together account for around 77% of euro area nominal gross value added.

efficiency of the economic process) for the period from 1991 to 1999. Usually TFP growth shows a pro-cyclical pattern. However, in view of the difficulties in separating trend from cycle, especially over short time periods, no attempt has been made to distinguish trend productivity growth from cyclical effects. Rather, the focus is on actual developments in the course of the 1990s. For the euro area, there is a scarcity of national accounts data on ICT investment. However, the euro area estimates presented below are based on national accounts data from four countries (Germany, France, Italy and the Netherlands), which together account for around 77% of euro area nominal gross value added.[5]

Table 5 presents the decomposition of growth of total real value added of the euro area estimate. The table presents absolute contributions to output growth, as well as relative contributions, which represent the share in total growth. It appears that the relative contribution of ICT capital to growth increased from 14% in the first half of the 1990s to 22% in the second half, largely owing to software and, to a lesser extent, information equipment. The contribution of communications equipment has been remarkably stable over time. The increased contribution of ICT capital to the growth of real value added has been accompanied

5 *See footnote 3.*

Box 3

Accounting for growth

In a growth accounting framework, the growth rate of output ($\dot{Y}$) is equal to the weighted growth rates of labour input ($\dot{L}$) and capital input ($\dot{K}$), plus growth in total factor productivity ($\dot{TFP}$). The following formula has been used here:

$$\dot{Y} = \alpha_L \dot{L} + \alpha_{K\text{-ict}} \dot{K}_{ict} + \alpha_{K\text{-other}} \dot{K}_{other} + \dot{TFP}$$

Labour input growth is measured in total hours worked. The share of labour (α_L) can be calculated from the wage share in gross value added (which can be directly extracted from the national accounts) adjusted for the imputed wage income of the self-employed. Owing to data limitations, no measure for the development of the quality of labour has been included in the exercise.

As regards capital inputs, a distinction is made between the contribution of ICT capital (K_{ict}) and that of other, non-ICT capital (K_{other}) to output. In all, six categories of capital have been distinguished. ICT capital consists of the stock of information equipment (including computers), the stock of software, and the stock of communications equipment. Non-ICT capital consists of the stocks of "other machinery and equipment", transport equipment and non-residential construction. The capital stocks have been constructed using the perpetual inventory method, which uses the past pattern of real investment and assumptions on service lives and age-efficiency patterns of the different types of capital goods. The sum of the shares of the various types of capital is assumed to be equal to 1- α_L, a standard assumption in this kind of exercise reflecting constant returns to scale. The relative weights of the different capital goods are based on the user cost of capital, i.e. the gross rate of return that must cover the internal rate of return (assumed common to all capital), the depreciation rate, and the capital gain/loss of the specific capital good.

Ideally, TFP growth should reflect the increase in efficiency in the economic process. Any positive spillover effects from ICT investment should thus be reflected in an increase in the estimate of TFP growth. However, as TFP growth is a residual term, it captures all elements not included in the growth rates of capital and labour inputs and thus also reflects the impact of omitted variables such as the quality of labour and any biases stemming for example from measurement problems. It is thus difficult to draw any firm conclusions from changes in measured TFP growth about the progress of overall efficiency.

by a decline in the absolute and relative contributions of non-ICT capital. The contribution of total hours worked to output growth turned positive in the second half of the 1990s, rising to 22% in relative terms, following a substantial decrease in hours worked in the first half of the decade. So far, there has been no evidence of an increase in TFP growth. On the contrary, TFP growth declined markedly in both absolute and relative terms in the 1995-99 period. In this context, it should be noted that the measure of TFP growth used here implicitly also includes changes in the quality of labour. In a situation of increasing labour market flexibility associated with rising employment also of relatively low-skilled and inexperienced people, the quality of labour input may grow at a slower pace than in a situation in which these people would not enter employment. Hence, the decrease in measured TFP growth in the second half of the 1990s is not necessarily a negative sign, as it probably also reflects the rise in employment.

A closely related exercise focuses on the decomposition of labour productivity growth, whereby the growth in total hours worked is subtracted from the growth in output and from the growth in the various inputs. Under this approach, growth in labour productivity reflects increases in the amount of capital available per hour worked (capital deepening) and the growth rate of TFP. Table 6 presents the results. It appears that labour productivity growth decelerated from 2.4% in the first half of the 1990s to 1.3% in the second half. This deceleration can be attributed to both a decline in TFP growth and a decrease in the rate of capital deepening of non-ICT capital. By contrast, the capital deepening of ICT increased over the same period from 11% to 30% in terms of relative contributions, in particular on account of software and information equipment.

Overall, these outcomes suggest that the importance of ICT capital accumulation for economic growth in the euro area increased in the second half of the 1990s. The euro area is thus experiencing positive growth effects from ICT. However, on the basis of the data available, it has not been possible to detect positive spillover effects from ICT investment on the rest of the economy, since, according to the estimates presented here, TFP growth did not increase in the course of the last decade.

Table 6

Decomposition of euro area labour productivity growth [1)]

	1991-95	1996-99	1991-95	1996-99
	absolute contribution to growth (percentage points)		relative contribution to growth (as a percentage of total)	
ICT capital deepening	0.26	0.39	11	30
- *information equipment*	*0.10*	*0.14*	*4*	*11*
- *software*	*0.10*	*0.21*	*4*	*16*
- *communications equipment*	*0.06*	*0.04*	*3*	*3*
Other capital deepening	0.73	0.28	30	22
TFP	1.41	0.61	59	47
	annual average percentage growth			
Labour productivity	2.4	1.3	100	100

Source: ECB calculations based on data from the OECD and national accounts.
Note: Figures may not add up due to rounding.
1) Euro area estimate based on France, Germany, Italy and the Netherlands, which together account for around 77% of euro area nominal gross value added.

4 Concluding remarks

The analysis of output and productivity developments in the euro area undertaken in this article suggests that in the period up to 2000 there were only very limited, if any, positive spillover effects from the use of ICT. For the period since then, based on partial information, there is no evidence that this picture would have significantly changed. There is thus no reason to believe that the growth rate of potential output of the euro area would have risen significantly in recent years as a result of ICT developments. However, at the same time, there is evidence of an increased contribution from ICT to overall economic growth.

Looking forward, it thus might be that the forces of technological change are already discretely operating in the background. An enhancement of structural reform in the euro area economies would clearly contribute to reaping the full benefits of the new technological possibilities. In this respect, it is somewhat disconcerting that, in the period examined, even the dynamic ICT producing sectors have not contributed to employment growth in the euro area. The introduction of new technologies requires flexible markets for other input factors, including labour, if production processes are to be organised more efficiently.

Taken on its own, however, the increased importance of ICT for economic growth in the euro area implies that the uncertainties surrounding estimates of medium-term developments in potential output growth have become skewed to the upside. Against this background, the ECB will continue to analyse closely whether the production and use of ICT will lead to an acceleration of productivity growth in the euro area.

The uncertainty surrounding the estimates of current or future potential output is one reason why the ECB treats these estimates with caution and does not mechanistically link its policy to them. Rather, the approach taken by the ECB in its two-pillar monetary policy strategy explicitly takes into account such uncertainty and thereby contributes to robust decision-making based on all available information. This enables the ECB to react flexibly to any new developments, including those which would signal an acceleration of productivity growth.