Measuring economic growth and the new economy

"In essence the question of growth is nothing new but a new disguise for an old-age issue, one which has always intrigued and preoccupied economics: the present versus the future".
– James Tobin, AER, 1964

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1. Introduction

For years the economics profession has been puzzled by one of the most perplexing economic problems – the overall slowdown in the growth rate of labour productivity since 1973. Not only was the deceleration a worldwide trend, the growth of productivity also turned out to be markedly slower in the US than in any other industrialized nation. In spite of many hypotheses, the phenomenon has remained, however, much of an academic mystery, often labelled with the analogy "death from a thousand cuts".

Yet today a reverse situation seems to have occurred. The contemporary brainteaser is indeed no longer why the US has been suffering from the slowest expansion of output per worker among the highly developed economies. Now the question is rather how the rapid increases in US labour productivity in the 1990s can be explained, and why other nations do not perform equally well.

At least there are some new hypotheses. Especially in the non-academic literature the most fashionable catchphrase is that a "new" economy has arrived in – and that it has been limited to – North America. Many commentators have now come to the belief that the prolonged expansion of the 1990s in the US owes something to innovative production and distribution processes, allowed by the use of computers, electronics and telecommunications in general, and to the wonders of the Internet in particular.

There may be some truth in this view. However, the cornerstone of the new economy idea – new technologies make firms more productive – is fiercely debated. Robert Gordon (2000), for instance, reports that in the US, productivity growth has been concentrated almost exclusively in the 1% of the economy that produces computers. Thus, computers have boosted productivity in the (re)production of more computers, but have not fostered comparable gains in other sectors of the economy. While Gordon's study cannot rule out future productivity increases, it debunks the celebrated conjecture that information and communication technology (ICT) productivity will trickle down to the whole economy – that is at best yet to come, but far from ascertained.

The current article adds to the growing literature that asks whether the performance gap between Europe and North America is really so large. Our main point is one of measurement issues. To be precise, we will document that a recent change to the system of business and national accounts, in combination with a different way of deflating ICT investment, may have substantially distorted perceptions regarding productivity growth. Against this background we will be able to put Europe's economic performance somewhat better into perspective.

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This paper investigates to what extent changes in statistical definitions have influenced measures for economic growth.

In order to do so, the paper is organized as follows. In the next section we will more rigorously define what we mean by a new economy, and investigate whether the official data confirm the implications. The main point, however, will be made in Section 3. Here, the latest modification to the system of national accounts is introduced. Also the impact of a hedonic deflator for ICT investment is presented. Against this background it is then investigated to what extent such changes may have affected measured total factor productivity growth. A final section summarizes and concludes.

2. The new economy gospel

What is in fact meant by a *new* economy? The popular buzzword has meanwhile been rigorously narrowed down in mainstream economics, as an economy in which *continued* – as opposed to temporary – gains in efficiency induce a more rapid expansion of labour productivity than in the economy that preceded it. As a consequence, at any given growth rate inflationary pressures are lower, and the NAIRU is also lower.

Thus, in a new economy one would like to observe a *permanent* upward trend shift in both total factor and labour productivity *growth*, without inducing higher inflation (1). But before we dive into deeper new economy waters to test these hypotheses, it is perhaps worth explaining why labour productivity growth is so crucial to an economy.

2.1 Why labour productivity growth is crucial to an economy

The following simplified identity may be helpful to answer this question.

$$\frac{\text{output}}{\text{hour}} = \frac{\text{wage}}{\text{hour}} = \frac{\text{profit}}{\text{hour}}$$

The identity merely says that in equilibrium firms will charge a mark-up over the wage cost when selling their turnover. In a capitalist environment – and in the absence of large productivity shocks that would induce substitution of capital for labour – competition and arbitrage possibilities will force profit rates to be fairly stable in the aggregate. Real wages and labour productivity must then clearly go hand in hand. Since most people receive the lion's share of their income from wages and salaries, productivity growth will hence determine how fast living standards are able to increase. Combined with the growth rate of the labour input (numbers of hours worked), the rate of growth of labour productivity also indicates how rapidly the economy's capacity to supply goods and services is increasing. The resulting figure is, of course, nothing but the growth rate of *potential* real GDP.

1) In fact, the definition also has two implications for the labor market performance. Firstly, the relation between growth and unemployment ("Okun´s law") should show a significant change in a "new" era. Okun´s law refers to the fact that as output rises in a cyclical recovery, additional workers are hired to produce it. As output falls in a recession, some workers are no longer needed and temporarily lose their jobs. This relationship thus is an obvious feature of the supply side of the economy, in the absence of productivity shocks. New technologies that would produce a benefical productivity shock - thereby triggering off a "new economy" - will clearly not affect this cyclical regularity. What would change is that the break point - the rate of growth at which unemployment neither raises nor falls - would become higher. Casual inspection of the data does not seem to suggest such a shift (see, for example, Krugman 1997). Secondly, the natural rate of unemployment should be affected.

So what can a society do to raise labour's productivity? There are – no more and no less – four alternatives:

- Physical capital deepening – i.e. to equip its workers with more and better physical capital (machines, tools, infrastructure and the like);
- Knowledge capital deepening – i.e. to improve the quality of the workforce through education and training;
- Foster a new economy – i.e. to improve the productivity of all the factors by introducing new technologies, so that given inputs produce more output;
- Grease the institutional cogwheels – i.e. to facilitate the working of the labour market, to limit economic distortions caused by taxes and passive labour market policies, to facilitate access to capital markets and so forth.

There are a number of European countries that outperform the American "new economy" as measured by the increases in TFP growth.

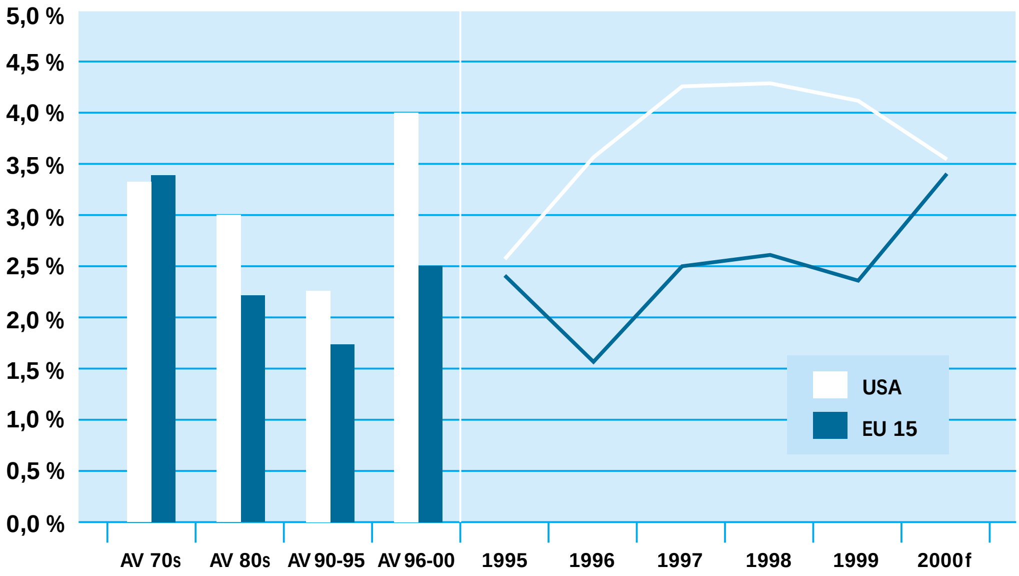
The first two options imply that some resources will be forgone and re-injected in the economy under the form of several types of investments. As a result more output will be reaped in the next period. Most empirical cross-country exercises tend to conclude that – together with a smooth working and competitive institutional setting (option 4) – continuous investment by the business sector has in fact been the most important force behind labour productivity growth in the "old" economy times (see e.g. Mankiw, Romer and Weil, 1992, or Barro and Sala-I-Martin, 1995). A previous edition of the *EIB Papers* (2000) has tackled this issue in greater detail. A "new" economy, by contrast, would be mainly characterized by a shift in total factor productivity growth – as mentioned in option 3 – due to network affects and the like. In the next section we will, therefore, focus on the structure behind labour productivity growth, that is, on the importance of capital deepening versus total factor productivity growth.

2.2 Casual empiricism

The official statistics on US growth performance have shown an astonishing performance for quite some time. With the current phase of expansion having started off in March 1991, the country's real GDP growth has increasingly outperformed the ones observed in the EU until mid-2000 (see Figure 1). For a mature economy, such a sustained accomplishment is unusual. Moreover, the United States have experienced a cycle that goes well beyond the economy's typical average of 45 to 50 months, and even surpassed what was observed in the golden 1960s.

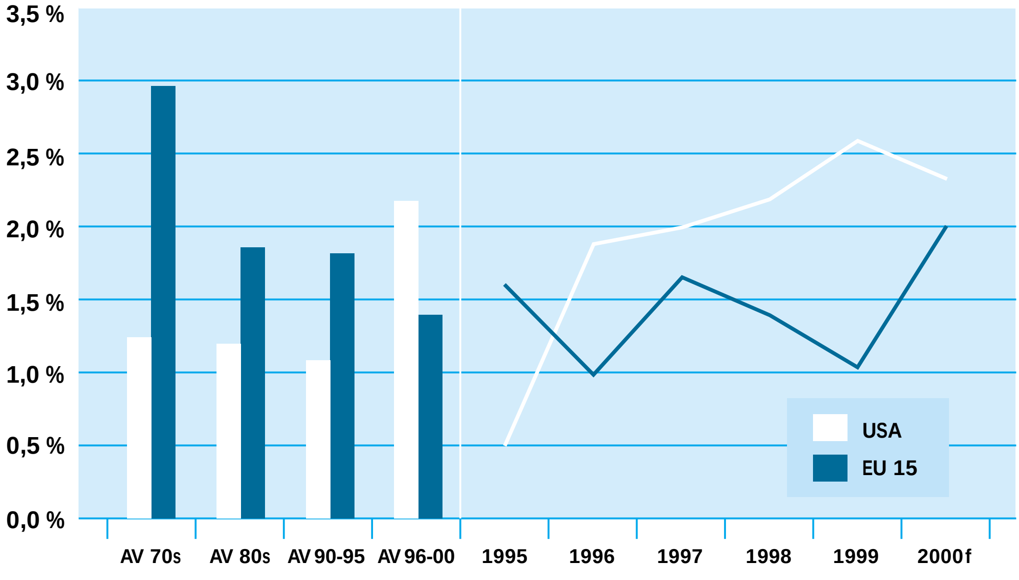
The surge in real labour productivity growth, however, mainly took place in the second half of the 1990s. The left panel in Figure 2 reveals for instance that the US was consistently lagging behind Europe until 1996 regarding its growth of output per worker. By contrast, in the second half of the 1990s the US trend has boosted well beyond what was observed across the Atlantic. Also the evolution of the trends is interesting. Whereas the EU has experienced a continuous slow down in real labour productivity growth, the US figures now fluctuate around 2.5 percent – more than twice as much as what was observed in the 1970s and the 1980s.

Figure 1. Real GDP growth



Source: AMECO

Figure 2. Real labour productivity growth as measured by output per employed person



Source: Staff calculations based on AMECO

Yet it would be too easy to infer from such a casual look at the official data that a fundamentally "new" economy is to stay in the US, or is skipping Europe. As we pointed out earlier, one should at least disentangle the performances into effects from capital deepening and other – fundamentally "new" – factors.

Table 1. Length of American business cycles in the "old" and "new" economy

Business cycle		Duration in months	
Trough from previous Peak	Trough to Peak	Contraction	Expansion
October 1945	November 1948	8	37
October 1949	July 1953	11	45
May 1954	August 1957	10	39
April 1958	April 1960	8	24
February 1961	December 1969	10	106
November 1970	November 1973	11	36
March 1975	January 1980	16	58
July 1980	July 1981	6	12
November 1982	July 1990	16	92
March 1991	???	8	117 (December 2000)
Average, all cycles			
1854-1991	(31 cycles)	18	35
1945-1991	(9 cycles)	11	50
Average, peace time cycles			
1854-1991	(26 cycles)	19	29
1945-1991	(7 cycles)	11	43

Source: Table taken from the NBER "US Business Cycle Expansions and Contractions".
Note: The NBER does not define a recession in terms of two consecutive quarters of decline in real GNP (i.e. negative growth). Rather, a recession is a period of significant decline in total output, income, employment, and trade, usually lasting from six months to a year, and marked by widespread contractions in many sectors of the economy.

2.3 A "new" economy? Capital deepening versus a structural change in total factor productivity

Perhaps the best tool in order to grasp the driving sources behind growth performance still is the old – yet elegant and well-established – technique of growth accounting. In this section we will present the results of such an exercise.

A "new" economy is characterised by a permanent upward shift in total factor productivity growth.

The standard framework starts off from the assumption that the evolution of output in the economy can be adequately captured with a production function of the Cobb-Douglas type:

(1) $$Y_t = A_t \cdot K_t^{a} \cdot L_t^{1-a}$$

where Y_t, K_t and L_t denote respectively output, physical capital and labour. The term A_t reflects efficiency gains that are not due to changes in the amount of employed production factors, and is referred to as total factor productivity (TFP). Note that this variable can capture anything ranging from technological change, over changes in the quality of labour to a more efficient institutional setting. While the parameter α denotes the degree to which the accumulation of production factors is subject to diminishing marginal productivity, the sum of the exponents for K and L reveals the extent to which there are returns to scale.

Moreover, if perfect competition prevails, then the marginal product of each input equals its factor price, so that:

(2) $\alpha = \frac{r \cdot K}{Y}$, the share of capital in output;

(3) $1-\alpha = \frac{w \cdot L}{Y}$, the share of labour in output

with r and w respectively the rate of return to capital and the wage rate.

Dividing both sides of the production function by the number of employed people yields an expression for labour's productivity:

(4) $\frac{Y_t}{L_t} = A_t \cdot K_t^{\alpha} \cdot L_t^{-\alpha}$

Taking logarithms and differentiating with respect to time results in growth rates (γ), which leads us to the following decomposition for labour productivity growth:

(5) $\gamma_{\frac{Y_t}{L_t}} = \gamma_{A_t} + \alpha \cdot \gamma_{K_t} - \alpha \cdot \gamma_{L_t}$

Thus, productivity growth ($\gamma_{Y/L}$) is the weighted sum of the percentage change in the net capital stock (γ_K) and employment (γ_L), plus the progress in total factor productivity (γ_A).

Other things being equal, a new economy would imply that its rate of growth of TFP (γ_A) would have settled at a higher level and explains now more of the labour productivity than before. Does it really? At least this framework suggests a straightforward way to check these hypotheses. From the previous equation it follows that TFP growth can be computed as the difference between labour productivity growth and the rate of change of the capital stock and the labour supply – each weighted accordingly.

Data on real labour productivity, employment and capital are readily available from the national accounts, for which we rely on the official AMECO database produced by the European Commission's DG EcFin. Time varying factor shares can be computed from that source, too. For instance, to obtain labour's share ($1-\alpha$) it suffices to divide the wage-sum by GDP – this value is typically round 2/3.

It should be noted that in these computations one assumes that the economy is operating at full capacity. Hence, some cyclical differences may affect the results and persistent underutilisation of some factors of production (i.e., EU unemployment) can also distort the overall picture. Another drawback of the approach is that all forms of capital are supposed to yield the same economic rate to return. Presumably public capital, private durables and ICT equipment differ in that respect substantially.

Bearing in mind these limitations, the implications of this exercise for TFP growth in the EU and the US are graphically presented in Figure 3. Table 2 below unveils the absolute and relative importance of both capital deepening and changes in TFP in the developments of their labour productivity over the last decades. The figures suggest that the TFP growth pattern and that of real GDP go hand in hand in recent years.

Table 2. Labour productivity (LP) growth in the EU and US decomposed

	Capital Deepening									
	Absolute contribution, in percentage points					*% of LP growth*				
	70s	80s	90s	*90-95*	*96-00*	70s	80s	90s	*90-95*	*96-00*
US	0.37	0.28	0.48	0.37	0.63	29.13	22.76	29.45	32.17	28.38
EU	1.16	0.66	0.68	0.87	0.44	39.59	36.46	42.50	48.88	31.88
	+ TFP growth									
	70s	80s	90s	*90-95*	*96-00*	70s	80s	90s	*90-95*	*96-00*
US	0.90	0.95	1.15	0.78	1.59	71.87	77.24	70.55	67.83	71.62
EU	1.77	1.15	0.92	0.91	0.94	60.41	63.54	57.50	51.12	68.12
	= Real labour productivity growth									
	70s	80s	90s	*90-95*	*96-00*	70s	80s	90s	*90-95*	*96-00*
US	1.27	1.23	1.63	1.15	2.22	100	100	100	100	100
EU	2.93	1.81	1.60	1.78	1.38	100	100	100	100	100

Note: Capital deepening is the contribution of capital-contribution of labour.
Source: Author's calculations based on AMECO data.

A striking fact is that TFP growth and capital deepening virtually doubled in the US in the last part of the 1990s.

The results also suggest a structural change in measured TFP growth in the US since 1996. It should be noted, though, that TFP continues to account for most of the labour productivity growth with a rather constant order of magnitude – it has explained a good 70 percent of the growth figure in the US and 60 percent in the EU throughout the last decades. The striking observation, however, is that both the contributions of TFP and capital deepening virtually doubled across the Atlantic during the last part of the 1990s. Recent research on the US economy reinforces our findings, as indicated in Table 3. The fast acceleration of TFP in the US needs to be contrasted with the rather stagnant TFP growth rate in Europe, and a falling capital deepening effect due to sluggish investment (2).

Nonetheless, the position of the EU should be put somewhat into perspective. For instance, it turns out that if one does a similar exercise at the level of Member States, a cluster can be detected that outperforms the American "new economy" as measured by the increase in TFP growth. Figure 4 reveals that this cluster mainly contains the Nordic countries, and also includes Ireland and

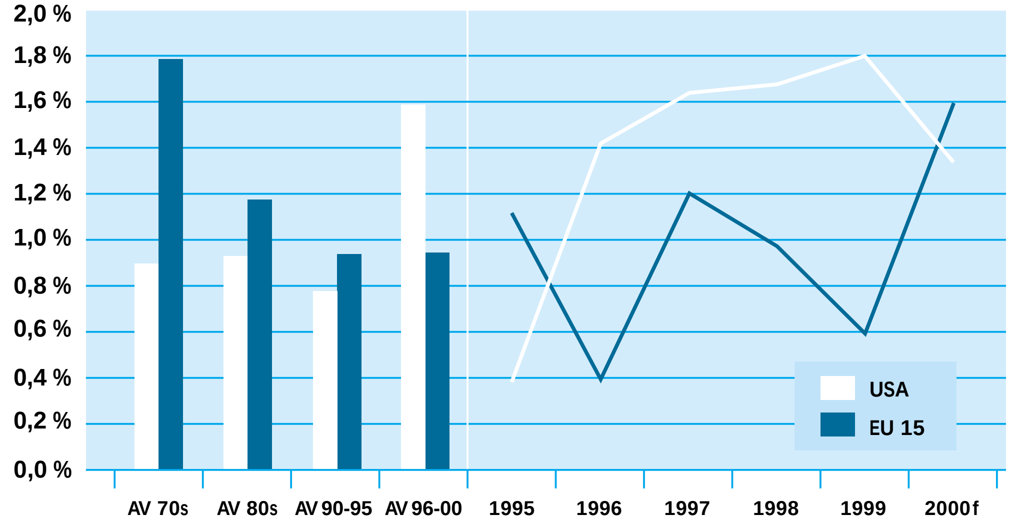
2) For instance, public investment went down from roughly 3 percent of EU GDP in 1990 to about 2 percent in 1998, because of restrictive fiscal policies due to EMU. See the EIB Papers *(2000).*

US labour productivity growth lagged behind Europe until 1996. However, the trend in US has been strongly reversed since then, whereas the EU has been facing a further slow down.

Luxembourg. The Netherlands and the UK follow the US closely, but their TFP growth has fallen somewhat behind what was observed in the 1970s. The largest EU economies, by contrast, have clearly suffered from a lower gear of their long-run growth engine compared to the 1970s. They have also experienced less acceleration in TFP growth than the other EU countries, which obviously affects the average for Europe as a whole negatively.

Finally, more refined calculations for TFP growth – that in various ways aim to correct for enhancements in human capital and labour force participation – turn out to be somewhat lower in general, but the pattern is the same.

Figure 3. TFP growth in the US and Europe



Source: Staff calculation based on AMECO

Figure 4. The new economy is observable in northern European economics

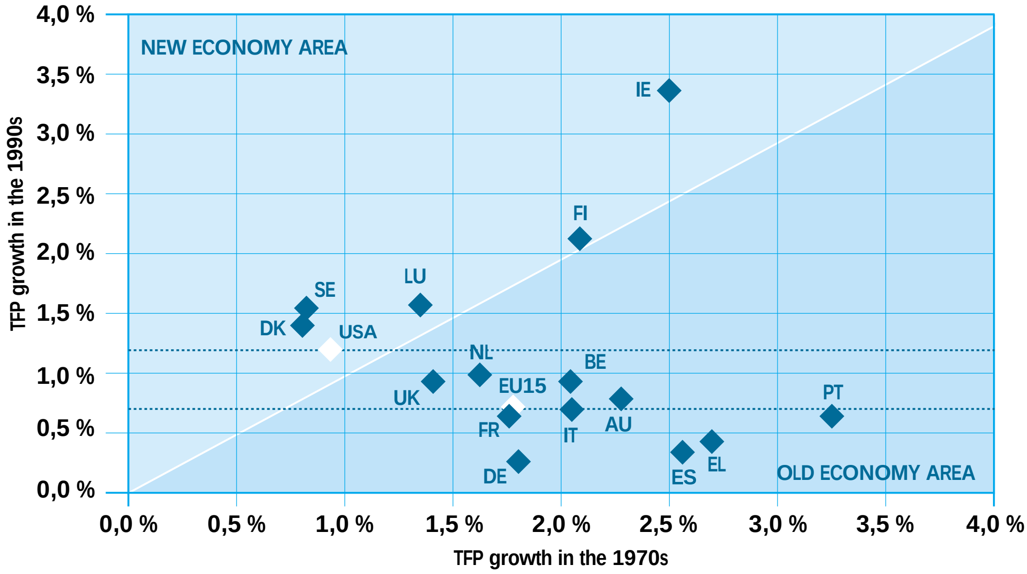


Table 3. Findings for US TFP growth rates

	Period	Contribution of TFP growth to LP growth in US not adjusted for labour quality	adjusted for labour quality
	1990-00	1.15 %	–
This study	*1990-95*	0.78 %	–
	1996-00	1.59 %	–
Scarpetta et al (2000)	1990-97	1.00 %	0.80 %
Jorgenson and Stiroh (2000)	1990-98	0.97 %	0.63 %
CEA * (2000)	1990-99	1.20 %	–
Oliner and Sichel * (2000)	*1990-95*	0.79 %	0.37 %
	1996-99	1.46 %	1.14 %
Bassanini *et al,* (2000)	*1995-98*	1.50 %	1.40 %
Gordon (2000)	*1995-99*	1.79 %	1.25 %

Note: *: non-farm business.

Can it be true that the new economy pattern is in part due to differences in accounting principles?

Hence an interesting fact remains: the US growth performance in terms of its total factor productivity – however measured – shows a much better picture since 1996 than what was recorded in earlier periods. Yet, if Gordon (2000), is right American TFP growth did not show up because of ICT network effects or external benefits that trickled down in the whole economy. According to his analyses it was rather the result of unusual growth in demand for computers and software. But is it really a mere coincidence that the principal acceleration in TFP growth happened in 1996 (see Figure 2)? Wouldn't one have expected a smoother transition given the fact that ICT equipment has been operational in the economy for decades already? To answer this, let us pursue here a different line of thought: can it be true that the recent apparent "new" economy pattern is due to differences in accounting principles?

3. A "new" economy? The impact of recent definitional changes in accounting principles

Three events may give this hypothesis at least some credibility. Firstly, private businesses have been allowed to capitalize software expenditures only since 1996. That is, whereas outlays for in-house developed as well as licensed and pre-packaged software were treated as any other business expense before 1996, they can now be amortized over their expected life time (see the Financial Accounting Standards Board). Such definitional changes will henceforth result in apparently rapidly increasing business investment when software expenditures grow swiftly, even when the quantity of goods produced per worker and total factor productivity remain constant. Secondly, the comprehensive revision in 1999 of the American National Income and Product Accounts (NIPAs) and their European counterparts (ESA) (3)

3) ESA is the Union's version of the United Nations system of national accounts (SNA), for which the guidelines are described in the United Nations' publication A System of National Accounts *(SNA). This document was first released in 1968 and substantially revised in 1993 under the auspices of the Intersecretariat Working Group on National Accounts, which consists of officials from the OECD, the International Monetary Fund, the United Nations Statistical Division, the World bank and the Commission of the European Communities. The first edition of the ESAwas in principle applied from 1970 (ESA70) and was followed by a second edition in 1970 (ESA79). In 1999, the third edition of the ESA(ESA95) was launched, and the new definitions are applicable for data starting from (at least) 1995. Eurostat collects ESA data by means of standardised questionnaires 6-13 months after the end of the year. When Member States do not provide all the required information, Eurostat attemts to produce estimates for the values, based on comparable trends and recent information.*

have only recently started to recognize outlays for software as gross fixed capital formation. Spending on software did not contribute to measured investment prior to these revisions, because it was considered to be an intermediate input like raw materials or electricity. Thirdly, since 1996 the US has moved away from using traditional deflators for IT and software.

The US national accounts have been modified to incorporate software outlays in aggregate investment. Europe has only recently begun to implement such definitional changes.

In what follows, it is useful to bear in mind that real GDP is computed as the sum of real consumption, real investment, real government expenditures and real net exports. Real labour productivity is subsequently derived as real GDP per worker (or per hour worked). Obviously, the change in accounting principles affects both nominal and real investment aggregates (gross fixed capital formation). In the rest of this section we will document in somewhat more detail how severely the aggregates have been influenced, after which we will analyse the impact of such modifications on measured TFP growth.

3.1 Software outlays are now considered as gross fixed capital formation

Both the private sector and the government spend large amounts each year on information technology. A study by the Bureau of Economic Analysis (Parker, 2000) reveals for instance that in the US, outlays on "hardware" (computers and peripheral equipment) amount to nearly 10 percent of that nation's non-residential investment – the equivalence of about 1 percent of its GDP.

Estimates show that current dollar investments for software by businesses and government increased rapidly from very small amounts in the late 1950s to about 1 billion USD in 1966. It continued to grow swiftly to more than 10 billion USD beginning 1979, and to some 180 billion in 1999 – that is roughly 2 percent of nominal GDP. Although growth rates have been large, they have diminished over time until the mid 1990s and increased rapidly thereafter.

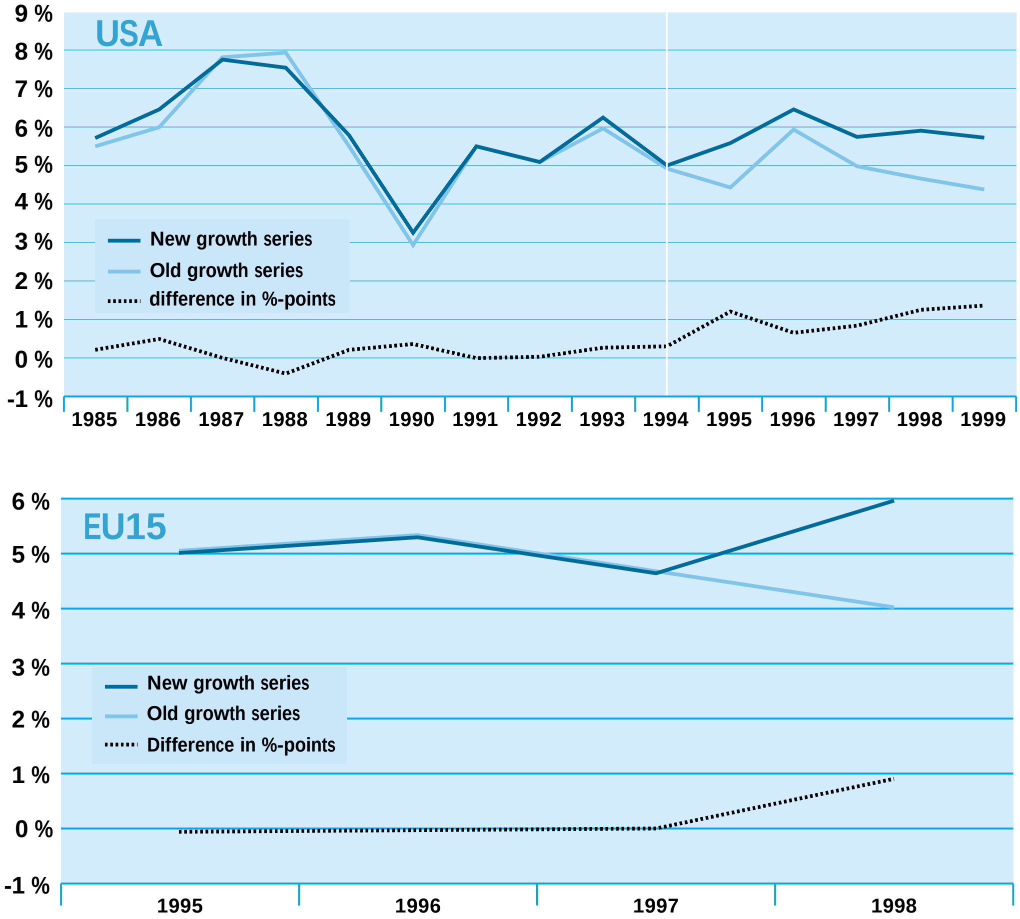
Table 4. Nominal average annual rates of growth for software investments in the US

Period	Nominal growth
1960-69	33.2%
1970-79	17.1%
1980-89	16.1%
1990-99	15.4%
1990-94	10.5%
1995-99	21.6%

Source: Parker, 2000.

All this makes, of course, that in addition to a level effect, shifting estimated software outlays from expenditures to investment also has an effect on rate of change of aggregate gross fixed capital formation. As a result, the revised treatment of software has increased the growth rate of GDP beginning with the first available year for software estimates in 1959. The impact of the changes on nominal GDP growth is presented in Figure 5, which shows a gain of about 1 percentage point to measured GDP growth during 1995-00.

Figure 5. Nominal GDP growth, new versus old NIPAs



Source: New Cronos, Eurostat.

Unfortunately the European System of Integrated Economic Accounts (ESA) has not yet gone through similar updates. That is, the framework has been developed (ESA95) and passed on to the Member States, but the actual data collection has only started recently. Based on rough estimates, the series on gross fixed capital formation has been recomputed back to 1995 to recognize software and hardware as investment. The collected information so far indicates that the benefits of measuring the EU economy better show up only as from 1997.

Cross-Atlantic differences in deflators used for the computation of real investment in ICT may bias the comparison of real productivity growth in the EU and US

3.2 Hedonic pricing of ICT equipment and software since 1996

In order to disentangle what part of the increase in nominal GDP is due to higher quantities, rather than to higher prices, one needs to correct for inflation of the various components of GDP. Statistical offices therefore build up the major aggregates from a large number of disaggregated component series, for which price information is collected at the same time. Real GDP at market prices is later constructed by adding up all the deflated aggregates. Yet cross-Atlantic differences for the computation of these deflators – in particular for ICT-equipment and software – importantly bias real growth and TFP comparisons between the EU and US.

One difficulty in splitting nominal increases in expenditures in their real and price components arises from changes in the quality of goods. This is a particular acute problem with ICT given the rapid technical advances that there have been. In the United States a so-called hedonic pricing mechanism – a theory pioneered by Zvi Grilliches, 1961 – has been employed for ICT goods since 1996. The main assumption behind the hedonic pricing technique is that the quantity of a particular commodity may be resolved into a number of characteristics that determine its quality. By means of regression analyses, part of the price is subsequently associated to each of the characteristics, so that variations in quality may be valued. For instance, suppose that a computer costs EUR 1 500 this year, and that one would pay the same price for a computer next year. However, the new PC would come with a processor of twice the capacity. Under a traditional method, the computers would be treated as the same volume with the same price. In a simplistic one-characteristic hedonic way, the real volume would have doubled while the price would have fallen to one-half.

The hedonic method is the main reason why the statistical price of computers has collapsed in the United States – notably by as much as a cumulative 80 percent in the 1990s (see Figure 6). Such fast decreases imply, of course, swiftly rising *real* IT expenditures and investment, which contribute to a higher measured *real* GDP. By contrast, the modest fall or even slight increases in producer prices of office, accounting and computing equipment in many European countries may be due to the predominant "conventional" method in deriving price indices. But just how different are the methodologies in Europe in this respect? A Task Force at Eurostat has tried to take stock of the discrepancies regarding the used approaches in the participating countries. Table 5 summarizes their findings, and has been augmented with information obtained from a study by the Board of the Federal Reserve, 2000.

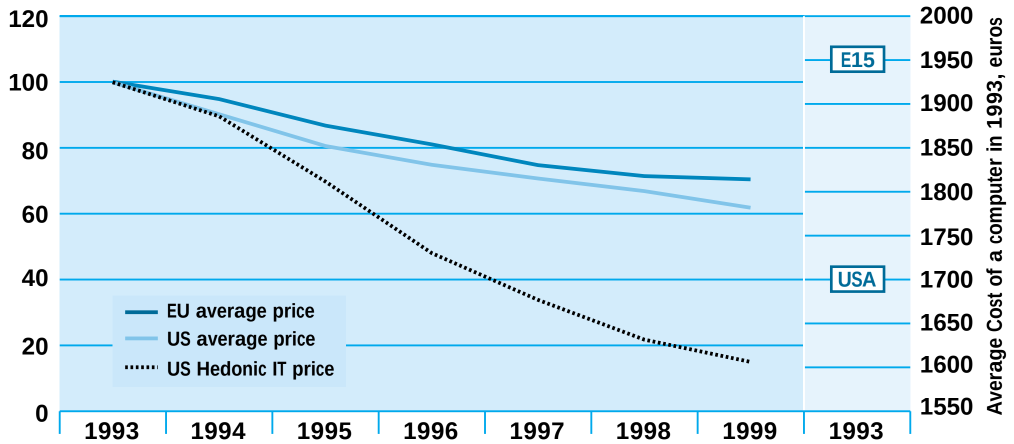
Table 5. Deflation practices for IT hardware in the Union

Country	Hedonic Price Index?	Source
Austria	No **	Eurostat
Belgium	No	Fed
Denmark	Yes *	Fed
Finland	No	Fed
France	Yes	Eurostat
Germany	No	Eurostat
Ireland	No	Eurostat
Italy	No	Fed
Netherlands	No	Fed
Spain	No	Fed
Sweden	Yes *	Eurostat
UK	No **	Eurostat

Source: Eurostat, 1999, Federal Reserve Board, 2000.
*: Uses current US hedonic index, exchange-rate adjusted.
**: Quality adjustments are done on a judgemental base.

In order to make the relative position of the US vis-à-vis the EU regarding real IT investment somewhat more comparable, we have computed an IT price index as nominal IT expenditures divided by number of shipments of new computers. The resulting "average" prices are contrasted with the hedonic series in Figure 6. Our index is clearly the opposite of a hedonic deflator, as it does not correct for quality changes whatsoever. But then again, with mainly new whistles and bells appearing in updated versions of software packages, have we really been doing different and more productive things over the last decade as newer generations of computers became available? Although correcting for quality improvements is attractive, hedonic pricing has indeed been criticised along these lines (see Gordon, 2000, for example). The discussion is unfortunately too cumbersome and would bring us beyond the scope of this paper.

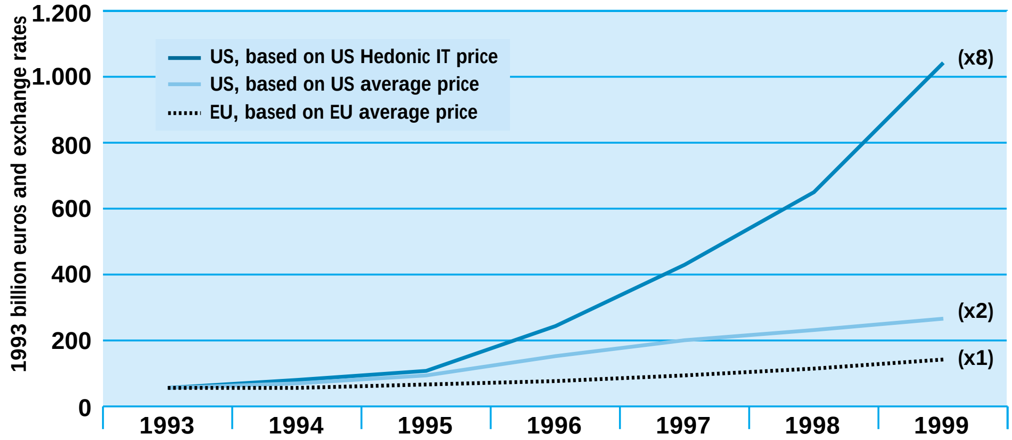
Figure 6. A hedonic versus an average price for IT equipment



Source: OECD, 2000 and Staff calculations based in EITO 2000 data.

However, the interesting tendency that appears from our exercise is that real IT investment has grown only little faster in the US than in the EU if one uses a common average price (4) (see Figure 7).

Figure 7. Real IT business sector investment

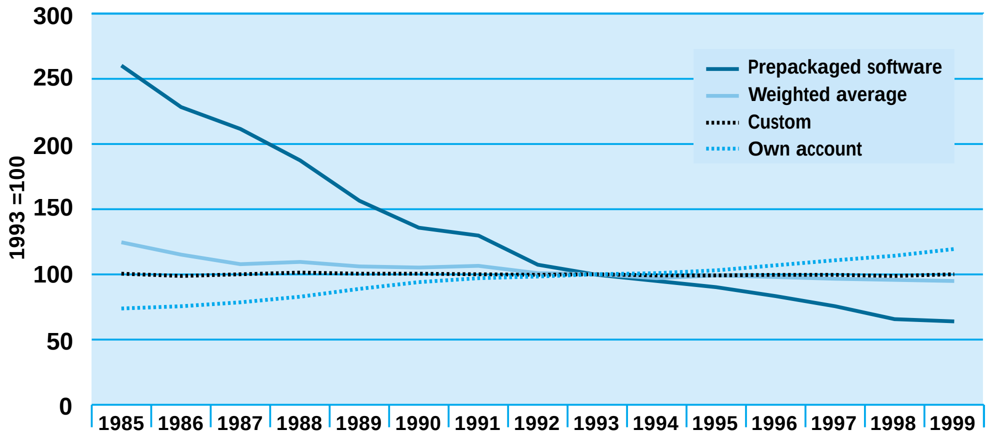


Note: IT business sector investment as a percentage of IT spending is taken from Daveri, 2000, who provides data for 1992 and 1997 (respectively 42.1 and 41.6 for the EU, and 36.4 and 44.3 for the US). To obtain investment figures, these data were interpolated in a linear way for other years, and then multiplied with IT expenditures as reported in EITO, 2000. The resulting series was subsequently deflated using the price indices reported in Figure 6.

4) In 1996, the US Department of Commerce also began using a new method to construct all aggregate "real" series in the NIPAs, that employs the so called "ideal chain index", which to some extent softens the hedonic impact. Whelan, 2000, shows however that mistaken calculations with the new "real" NIPAs have become very common. A more careful treatment of these data shows for instance that, in terms of actual dollars spent,the increase in the role of information technology has been more modest than one might think: "While the (essentially meaningless) ratio of real 1992-dollar information processing investment to aggregate real equipment investment goes from 0.07 in 1970 to 0.50 in 1998, the corresponding nominal ratio only changes from 0.22 to 0.34 over the same period. As a result of the introduction of software as a capital asset in the October 1999 revision, the most recent NIPA data show this share increasing from 0.24 in 1970 to 0.44 in 1998".

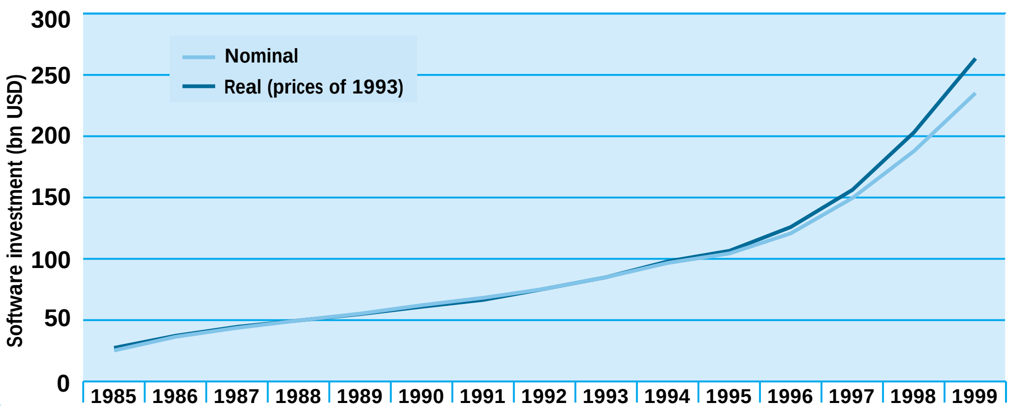
As regards software, three different types are distinguished: 1) pre-packaged software – i.e. software intended for non-specialized uses, sold or licensed in standardized form – 2) own-account software – software developed within a company for their own use by means of in-house expenditures – and 3) custom software – a mixture of new programming and existing programs or program modules that are incorporated into new systems, tailored to the specifications of a business enterprise or government unit. The deflators used for each category vary between the two extremes. Price corrections for pre-packaged software, for instance, are done in a hedonic way. For own account software investments, an input-cost index is used that is calculated from a weighted average of a) compensation rates for computer programmers and system analysts and b) the intermediate inputs associated with their work. Finally, the price index for custom software is constructed as a weighted average of the previous two. The weights, which are selected arbitrarily, are 75 percent for changes in business own-account software prices and 25 percent for changes in pre-packaged software (see Parker, 2000). The various price indices are shown in Figure 8. With pre-packaged software accounting for roughly 30 percent of the total in the 1990s, the average price deflator for recent software investment is for nearly two-thirds estimated under the assumption of no gain in productivity. As a result, the difference between nominal and real investments for software is not as spectacular as that observed for hardware (see Figure 9).

Figure 8. A partially hedonic price index for software investments



Source:Parker (2000).

Figure 9. Real and nominal software investments in the US



In sum, although the new system of national accounts may perhaps describe the economy better than the old one, the combination of using a rapidly falling hedonic price deflator for hardware and – to a more limited extent – software investments also has an important drawback. It introduces a potentially serious bias in international comparisons with countries where such techniques are not (yet) used.

3.3 Do modifications in the accounting principles affect measures for TFP growth?

Let us now come back to our initial question: can it be true that the gap between the EU and US in terms of an apparent "new" economy pattern – a surge in TFP growth – is in part caused by simple accounting principles? If so: how much is attributable to measurement issues?

The various statistical alterations permanently revise measured capital deepening and TFP growth upwardly.

In order to investigate this, recall that TFP growth is typically computed in a neoclassical framework as described earlier. Thus, what we need to investigate is twofold. Firstly, how are measures for changes in TFP and capital deepening in a growth accounting exercise affected by adding software expenditures to both GDP and the capital stock? Secondly, how does the deflator for software and hardware influence those measures?

The formal derivations of the impact of such changes on growth accounting outcomes are presented in the Box. Apparently a more rapid price decline for information technology has two direct effects on the sources of growth. The intuition is that adding in software investments as well as the alternative investment deflators raises real output growth by reallocating nominal growth away from prices towards quantities. In addition, larger investment quantities each year increase the growth rate of the capital stock. Since output is not a linear function of the capital stock, the modifications may have an impact on both capital deepening and TFP growth. It is worth stressing that changes in the accounting principles as well as pricing hedonics permanently revise measured TFP growth and the capital deepening effect upward.

Guestimates based on plausible numbers for the US economy reveal that the impact of these changes in definition was non-trivial. For instance, the Box shows that the theoretical gains of adding software for the period 1996-98 mounted to slightly over four tenths of a percentage point for TFP growth – hedonics added another two tenths of a percentage point. The impact on capital deepening has remained small.

As for the acceleration of TFP and capital deepening between 1990-95 and 1996-98, the final effect is significant. If one adjusts for pricing hedonics, the "real" acceleration is at best only half the size of what the current official data reveal. The change in capital deepening drops to zero if one also filters out the impact of adding software, and, in that case, the increase in TFP stands only at a quarter of the officially measured acceleration. With these findings we are now better able to compare like with like, that is, to compare the growth accounting findings for the EU with the corrected ones for the US. Table 6 reports these results – more details can be found in the Box.

Table 6. The impact of definitional changes

1996-98	Capital deepening	TFP growth	LP growth
US official data	0.43 %	1.60 %	2.03 %
less impact of hedonics =	0.41 %	1.19 %	1.60 %
less impact of software =	0.37 %	1.02 %	1.39 %
EU official data	0.45 %	0.84 %	1.29 %

The stagnant TFP growth for the EU as a whole that arises from a casual look at the official data should therefore be interpreted with great caution, and should not be taken as a dramatic fall behind yet. Based on TFP growth performances our findings rather suggest that the "Nordic cluster" in Figure 3 – where hedonic pricing is not used apart from Denmark and Sweden – may perhaps be a better example of a "new" economy than the US.

4. Conclusion

In this paper we started off from the observation that official data reveal an extraordinary shift in US total factor productivity growth (TFP) in 1996, which led to important gains in labour productivity growth in the second half of the 1990s. Europe as a whole did not benefit from such a structural break. The continent's national accounts rather show a stagnant TFP growth, and a falling capital deepening effect. However, it was shown that a Nordic EU cluster substantially outperformed the US in terms of TFP growth in the 1990s.

At the same time, swelling expenditures for ICT have gone hand in hand with a surge in the American economic performance. The perception therefore is that the growth of digital economic activities has been unprecedented and has been a major contributor to this phenomenon. Since Europe's business investment in IT is lower than the one observed in the US, the fear is that the EU will fall behind regarding labour productivity growth.

We then wondered whether it was really a mere coincidence that the principal acceleration in American TFP growth happened precisely in 1996. After all, one may have expected a smoother transition given the fact that ICT equipment had been operational in the economy for decades already. The line of thought that was followed subsequently raised the question whether the structural shift may have had something to do with the change in business and national accounting principles – now software expenditures are considered to be fixed capital formation – and the move away from traditional deflators towards hedonic pricing techniques. All these events incidentally also started in 1996, but the hedonic pricing techniques are not yet adopted by the Member States (except for Denmark, France and Sweden).

Our analysis shows that such definitional changes do have an impact on measured TFP growth – they will *permanently* revise TFP and labour productivity growth upwards. Guestimates based on recent data reveal that the bonus has been four tenths of a percentage point since 1995. Hedonic pricing has added another two tenths of a percentage point. In any case, the accelerations in TFP growth are at best only half the size of what is implied by the official data.

In international comparisons one should compare like with like. If one corrects for differences in definitions, the gap between the EU and US becomes smaller.

Our results do not intend to put the recent statistical changes in a bad daylight – the modifications undoubtedly contribute to a more accurate measurement of the economy. However, international comparisons should compare like with like. We documented that if one does correct for the increase in growth due to changes in definitions, the gap between the EU and the US becomes smaller. The trend in TFP and labour productivity growth in the US remains, however, positive.

Box 1. Impact of the definitional changes on TFP growth and capital deepening

Let Y_{old} denote real GDP and K_{old} the capital stock –i.e. the sum of non-IT and IT equipment – *before* software outlays were added as investment. Clearly,

$$Y_{new} \equiv Y_{old} + \frac{S}{p_S} \quad \text{and} \quad K_{new} \equiv \frac{K_{old}}{p_K} + \frac{S}{p_S}.$$

In these definitions S stands for the current stock of software capital with the associated price level p_S, while p_K symbolizes the weighted average price level for total capital. Hedonic pricing of IT-equipment obviously has an impact on p_K proportional to the weight of IT in the total capital stock.

In terms of a growth accounting exercise, the production function now is:

$$Y_{new} \equiv Y_{old} + S/p_S = A_{new}.(K_{old}/p_K + S/p_S)^{\alpha}.L^{1-\alpha}$$

Consequently, the level of labour productivity that needs to be decomposed reads:

$$\frac{Y_{new}}{L} \equiv \frac{Y_{old}}{L}.\left(1+\frac{S/p_S}{Y_{old}}\right) = A_{new}.\left(\frac{K_{old}/p_K}{L}\right)^{\alpha}\left(1+\frac{S/p_S}{K_{old}}\right)^{\alpha}$$

In what follows we will use lower case letters to denote per capita variables. Taking logs and time derivatives, and using the approximation $\ln(1+x) \approx x$, yields an expression for the growth rate of labour productivity (g_y):

$$g_{y_{new}} \equiv g_{y_{old}} + \frac{d}{dt}\left(\frac{S/p_S}{Y_{old}}\right) = g_{A_{new}} + \alpha.\left(g_{k_{old}} - g_{p_K}\right) + \alpha.\frac{d}{dt}\left(\frac{S/p_S}{K_{old}/p_K}\right)$$

After having worked out the time derivatives, one finally obtains:

$$g_{y_{new}} \equiv g_{y_{old}} + \frac{S/p_S}{Y_{old}}.\left(g_S - g_{p_S} - g_{Y_{old}}\right)$$

$$= g_{A_{new}} + \alpha.\left(g_{k_{old}} - g_{p_K}\right) + \alpha.\frac{S/p_S}{K_{old}/p_K}.\left(g_S - g_{p_S} - g_{k_{old}} + g_{p_K}\right)$$

It becomes visible that the definitional changes affect both TFP growth and capital deepening. The table bellows summarizes the impacts.

System:	Capital deepening	TFP growth
Old	$\alpha.\left(g_{K/L_{old}} - g_{p_K}\right)$	$g_{Y/L_{old}} - \alpha.\left(g_{K/L_{old}} - g_{p_K}\right)$
New	$\alpha.\left(g_{K/L_{old}} - g_{p_K}\right)$ $+\alpha.\frac{S/p_S}{K_{old}/p_K}.\left(g_S - g_{p_S} - g_{K_{old}} + g_{p_K}\right)$	$g_{Y/L_{old}} - \alpha.\left(g_{K/L_{old}} - g_{p_K}\right)$ $+\frac{S/p_S}{Y_{old}}.\left(g_S - g_{p_S} - g_{Y_{old}}\right)$ $-\alpha.\frac{S/p_S}{K_{old}/p_K}.\left(g_S - g_{p_S} - g_{K_{old}} + g_{p_K}\right)$
Bonus	$+\alpha.\frac{S/p_S}{K_{old}/p_K}.\left(g_S - g_{p_S} - g_{K_{old}} + g_{p_K}\right)$	$\frac{S/p_S}{Y_{old}}.\left(g_S - g_{p_S} - g_{Y_{old}} - \alpha.\frac{Y_{old}}{K_{old}/p_K}.\left(g_S - g_{p_S} - g_{K_{old}} + g_{p_K}\right)\right)$

Introducing hedonics – resulting in a faster negative growth rate for p_K and p_S than obtained with a traditional deflator – has clearly an impact on both capital deepening and TFP growth. Both factors are also put on a higher level than what was previously observed due to accounting software outlays as investment. For instance, the TFP growth path is a function of both the size of real software outlays relative to the (old) real GDP, and the growth rate of software outlays. The capital deepening effect is multiplicatively related to the size of real software investment as a percentage of the real (old) capital stock, and the growth rate of software investments.

Just how large is the bonus? The table below reports in this respect the necessary figures for the computations. They are taken from Parker, 2000, Jorgenson and Stiroh, 2000, and Eurostat for the ESA79 definitions. In combination with these data, the IT hedonic and average price indices reported earlier in this paper were used in order to compute the weighted price index for capital. As for software, the non-hedonic price index applied is the one for own-account software while the hedonic series refers to the weighted average of the indices for own-account, custom and pre-packaged software as mentioned in the main text.

	S (bn USD nominal)	g_S (% nominal)	Y_{old} (bn USD real, p95)	$g_{Y_{old}}$ (% real, p95)	K_{old} (bn USD nominal)	$g_{K_{old}}$ (% nominal)
1998	422.03	18.50%	7744.51	2.70%	27367.80	7.00%
1997	364.04	15.93%	7453.81	3.90%	25555.79	7.09%
1996	323.26	12.62%	7198.31	3.55%	23837.81	7.21%
1995	289.94	11.49%	7029.60	2.40%	22925.98	3.98%
	p_S index 1995=100	g_{Sh} index 1995=100	p_K index 1995=100	p_{Kh} index 1995=100		
1998	104.78%	94.30%	109.57%	109.09%		
1997	103.14%	96.50%	105.42%	105.05%		
1996	100.81%	98.37%	101.23%	101.01%		
1995	100.00%	100.00%	100.00%	100.00%		
	g_{PS} **%**	g_{PSh} **%**	g_{PK} **%**	g_{PKh} **%**		
1998	2.85%	0.15%	3.74%	3.50%		
1996	1.60%	-2.28%	3.94%	3.85%		
1996	2.31%	-1.90%	4.14%	4.00%		
1995	0.81%	-1.63%	1.23%	1.01%		

the subscript h denotes hedonic pricing

Plugging these figures into the above formulas, and assuming 1/3rd for α, leads to the following impacts:

Bonus	capital deepening	+ TFP growth	= LP growth	capital deepening	+ TFP growth	= LP growth
	non-hedonic prices			hedonic prices		
1998	0.07%	0.61%	0.67%	0.09%	0.82%	0.90%
1997	0.05%	0.44%	0.49%	0.08%	0.65%	0.72%
1996	0.03%	0.27%	0.30%	0.05%	0.45%	0.50%
1995	0.03%	0.31%	0.34%	0.04%	0.40%	0.44%
average	0.04%	0.41%	0.45%	0.06%	0.58%	0.64%

If one adds these bonuses to the actual reported averages for 1990-95, the predicted averages for 1996-98 are 0.43% for the capital deepening effect, 1.36% for TFP growth – in sum a labour productivity growth of 1.79%. Again, the increase in these figures is only due to the changes in definitions. Incidentally, with the official statistics on labour productivity growth standing at 2.03%, a growth accounting exercise shows a measured average increase of 0.43% for capital deepening and 1.60% for TFP growth.

	Capital deepening	TFP growth	LP growth
	theoretical averages for 1996-98:		
(A) official average 90-95	0.37 %	0.78 %	1.15 %
(B) plus software =	0.41 %	1.19 %	1.60 %
(C) plus hedonics =	0.43 %	1.36 %	1.79 %
	official averages for 1996-98:		
(D) official average 96-98	0.43 %	1.60 %	2.03 %
	official acceleration between 90-95 and 96-98:		
(D)-(A)	0.06 %	0.82 %	0.88 %
	"real" acceleration between 90-95 and 96-98 after correcting for		
hedonics **[(D)-(B)]**	0.02 %	0.41 %	0.43 %
hedonics and software **[(D)-(C)]**	0.00 %	0.24 %	0.24 %

This would imply that the "real" gains in the economy – that is, after having filtered out gains from changes in the accounts and pricing techniques – mount to zero for capital deepening and approximately a fourth of a percentage point for TFP growth. If one only corrects for hedonic pricing techniques, by contrast, the gains are two tenths for capital deepening, and four tenths for TFP growth. However, the "real" accelerations are at best only half as large as what the official statistics reveal.

With these findings we are now better able to compare like with like. Since neither hedonic prices nor software investments were apparent in the EU accounts before 1998 we may compare the European growth accounting findings with the fully corrected ones for the US:

	Official data			Common definition		
Capital deepening						
	90-95	96-98	*Acceleration*	90-95	96-98	*Acceleration*
US	0.37	0.43	+0.06	0.37	0.37	+0.00
EU	0.87	0.45	–0.42	0.87	0.45	–0.42
TFP growth						
	90-95	96-98	*Acceleration*	90-95	96-98	*Acceleration*
US	0.78	1.60	+0.82	0.78	1.02	+0.24
EU	0.91	0.84	–0.07	0.91	0.84	–0.07
Labour productivity growth						
	90-95	96-98	*Acceleration*	90-95	96-98	*Acceleration*
US	1.15	2.03	+0.88	1.15	1.39	+0.24
EU	1.78	1.29	–0.49	1.78	1.29	–0.49

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