Will the Real Economy Please Rise?
Assessing the Impact of Changes in the System of National Accounts in A Simple Endogenous Model, and in a Growth Accounting Framework

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Abstract

The current article investigates whether the performance gap between Europe and North America is really as large as what the official data seem to suggest. To be more precise, we will show that recent changes to both the system of business and national accounts, in combination with a different way of deflating ICT investment across the Atlantic, may have caused a permanent upward shift in measures for total factor productivity (TFP). The analysis reveals that higher measured American TFP growth in the late 1990s was for about 50% due to statistical modifications that are not yet fully operational in Europe.

Key words:
Endogenous growth, two-sector growth model, growth accounting, national accounts, investment, ICT equipment, measurement error.

JEL-classification codes:
O41, O47, O51, O52

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1 Introduction

There are three remarkable facts about the recent evolution of the US economy. Firstly, growth accounting exercises strikingly show that capital deepening and total factor productivity (TFP) growth have followed a step function during the 1990s. That is, they have virtually doubled between 1994 and 1995, and have remained at their new level thereafter. Their relative contribution to growth, however, has not changed since the 1970s (see e.g. Oliner and Sichel, 2000, Vanhoudt and Onorante, 2001). Especially the permanent increased rate of TFP growth is taken as a sign of a "new economy".

It is the view of many US commentators that this remarkable American performance was brought about by network externalities due to the increase in expenditures for Information and Communication Technologies (ICT). There may be some truth in this view. However, if network externalities were to be key to this result, one would have expected a smooth transition of TFP growth. After all, ICT goods have been around for several decades albeit with lower performance and capacity. The cornerstone of the new economy idea – new technologies make firms more productive – is indeed fiercely debated. Robert Gordon (1999), 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.

Secondly, there have been important changes to business and national accounting principles. Private businesses have been allowed to capitalize software expenditures precisely as from 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. Obviously, such definitional changes will 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 remains constant.

The US national accounts have been modified to incorporate software in aggregate investment since the 1999 comprehensive revision. Note that spending on software did not contribute to measured investment or GDP prior to these revisions, because it was considered to be an intermediate input like raw materials, electricity, or intangibles such as human capital or R&D. Europe, by contrast, has only begun to implement such definitional changes.

Finally, since 1996 the US has moved away from using traditional deflators for IT and software. In Europe only Denmark, France, and Sweden follow such a methodology.

The current article therefore adds to the growing literature that asks whether the performance gap between Europe and North America is really as large as what the official data seem to suggest. More specifically, this paper addresses the question to what extent the definitional changes since 1995 have contributed to the step function in measured TFP – the new economy pattern – observed in the second half of the 1990s.

In order to do so the paper is organized as follows. We will first start by setting out a two-sector growth model. The aim here is to endogenize "total factor productivity A" in the simple Solow specification Y=A F(K,L). To be precise, A is considered to be intermediary supply of software. The key conclusion is that – even if software is produced under increasing returns to scale – a steady state may exist, where the positive and constant rate of growth of labor productivity is independent of software expenditures. We will thereafter show that in that case, a modification in the system of national accounts that treats the output of the software sector as investment, rather than intermediary consumption, may mistakenly lead to a "new economy" conclusion. We will do so both in an analytical way as by means of simulations of the model.

In order to compare like with like we finally set up a system of growth accounting for the EU and the US, both with and without definitional changes and deflator principles. It will become clear that higher measured American TFP growth in the late 1990s was for about 50% due to statistical modifications that are not yet fully operational in Europe.

2 A simple endogenous growth model with software as an intermediary input

2.1 A 2-sector endogenous growth model

The main question in this section is whether the rapid growth of the software-producing sector is unequivocally related to an economy's long-run growth performance from a theoretical point of view. The aim of this section therefore is to endogenize "total factor productivity A" in the simple Solow specification Y=A F(K,L). That is, we will treat A as intermediary supply of new software.

The set-up we will use is the following. Let us for simplicity start off with the assumption that there are only two sorts of capital goods used in the economy: software (T) on the one hand, and "other" physical capital (K) on the other. There are also only two sectors: a final goods producing sector (Y), and an intermediary goods producing sector that develops software. Both sectors use a certain fraction of the total stock of K, T and labor (L) to work with. To be precise, the goods producing sector uses a fraction $(1-a_L)$ of the labor force, a fraction $(1-a_K)$ of the available physical capital, and its share of software input mounts to $(1-a_T)$. [1] Thus, the quantity of output produced (GDP) at time t is:

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[1] We assume that the shares a_K, a_L and a_T in the production functions are at their equilibrium value. Clearly, one could endogenize these shares so that they would be potentially time varying as they would be a function of their relative input prices. However, their equilibrium values would eventually turn out to be constant, so that endogenizing them does not contribute much to the main point we want to make.

(1) $$Y_t = [(1-a_T)\cdot T_t]^{\beta}[(1-a_K)\cdot K_t]^{\alpha}[(1-a_L)\cdot L_t]^{1-\alpha-\beta}, \qquad 0<\alpha+\beta<1$$

Note that, $A_Y=\{(1-a_T).T_t\}^{\beta}$ is what would be reported as total factor productivity in a growth accounting exercise where $Y=A_Y\ F(K,L)$; TFP growth would equal $\beta.g_T=\beta.dt/T.1/T$, and would mainly arise from producing more T over time. An economy would henceforth experience a certain constant measured rate of TFP growth in its steady state, provided that statistical definitions would remain consistent over time.

We assume that the production of final goods takes place under constant returns to scale. That is, there are no network effects from using software – or ICT in general. This feature is conform with Gordon's observations (1999) in the US, where ICT capital has so far induced only limited network externalities throughout the economy.

At the same time, the production of new software – an intermediary capital good in this context – depends on the quantities of physical capital and labor involved, but also on the availability of software itself. To put it differently: inventing a new software package is easier if you have already pre-programmed codes around. Arguably, developing new software involves a technical process that is characterized by overall increasing returns to scale. Consequently, we describe output of software, per unit of time, by:

(2) $$\frac{dT}{dt} = A_T\cdot[a_T\cdot T_t]^{\delta}\cdot[a_K\cdot K_t]^{\gamma}\cdot[a_L\cdot L_t]^{\phi}, \qquad 0<\delta,\gamma,\phi<1,\ \phi>1-\delta-\gamma$$

Finally, A_T is a shift parameter reflecting productivity gains in the software sector that are caused by other things than changes in the quantity of used production factors (e.g. a more efficient production structure, better management, higher human capital of the workforce, etc) [2].

Changes in the stock of physical capital come per definition from investment, for which we assume an exogenous and constant investment rate: every period of time a fraction s of the produced goods is not consumed, but re-injected in the economy to build physical capital. We will for further simplicity abstract from depreciation, and will treat population growth as exogenous.

(3) $$\frac{dK}{dt} = s\cdot Y_t$$

(4) $$\frac{dL}{dt} = n\cdot L_t$$

Consequently, this framework provides us with 2 stock variables, K and T, whose behavior is endogenous – that is, depending on other variables in the model – and whose levels (K,T) and growth rates (g_K, g_T) are key to the evolutions of the

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[2] Note that – although there can be overall increasing returns to scale to *produced* factors K and T (i.e. $\alpha+\beta+\delta+\gamma>1$) – we presume that all inputs are characterized by diminishing marginal product. In fact, as will become clear later, positive endogenous growth requires that production of software does *not* take place under constant returns to scale.

economy's GDP per worker (Y/L). We thus need to investigate how g_K and g_T behave in order to understand what will happen to the economy.

Dividing equation (3) by K yields an expression for the growth rate for the stock of physical capital:

(5) $$g_K = \frac{dK}{dt}\frac{1}{K} = c_K \left[\frac{T_t}{L_t}\right]^{\beta} \Big/ \left[\frac{K_t}{L_t}\right]^{1-\alpha}, \qquad c_K = s.(1-a_K)^{\alpha}.\ (1-a_T)^{\beta}.(1-a_L)^{1-\alpha-\beta}$$

Clearly, this growth rate depends on the ratio of software per worker, to "other" capital per worker, be it not in a linear way. By solving $d\ln(g_K)/dt = 0$ we can find the combinations of g_K and g_T for which capital will remain growing at the same pace forever:

(6) $$g_K = \frac{1-\alpha-\beta}{1-\alpha}\cdot n + \frac{\beta}{1-\alpha}\cdot g_T,$$

This 0-locus is a straight line with positive slope and intercept. Since we know that final production takes place under constant returns to scale, we have that $\alpha+\beta<1$, or that $\beta<1-\alpha$, so that the slope of this line is less than 45 degrees.

Evidently, the rate of growth with which physical capital changes will remain the same over time *only* for combinations of g_K and g_T that are situated on this line. Suppose for a moment that there would be a different combination of growth rates in the economy, for instance situated below this line. Here, output of software packages grows too fast to keep the growth rate of the capital stock unaffected. The amount of non-consumed output (s.Y) increases, so that the growth rate of K speeds up. The opposite logic holds above the line.

Let us turn now to the behavior of the growth rate for software following the same logic. Dividing equation (2) by T yields this growth rate:

(7) $$g_T = \frac{dT}{dt}\frac{1}{T} = c_T \cdot T_t^{-(1-\delta)} \cdot K_t^{\gamma} \cdot L_t^{\phi}, \qquad c_T = A_T.a_K^{\gamma}.a_T^{\delta}.a_L^{\phi}$$

Obviously, $d\ln(g_T)/dt=0$ results in

(8) $$g_K = -\frac{\phi}{\gamma}\cdot n + \frac{1-\delta}{\gamma}\cdot g_T,$$

This 0-locus also is a straight line, but with a different slope and intercept than the one we came across earlier.

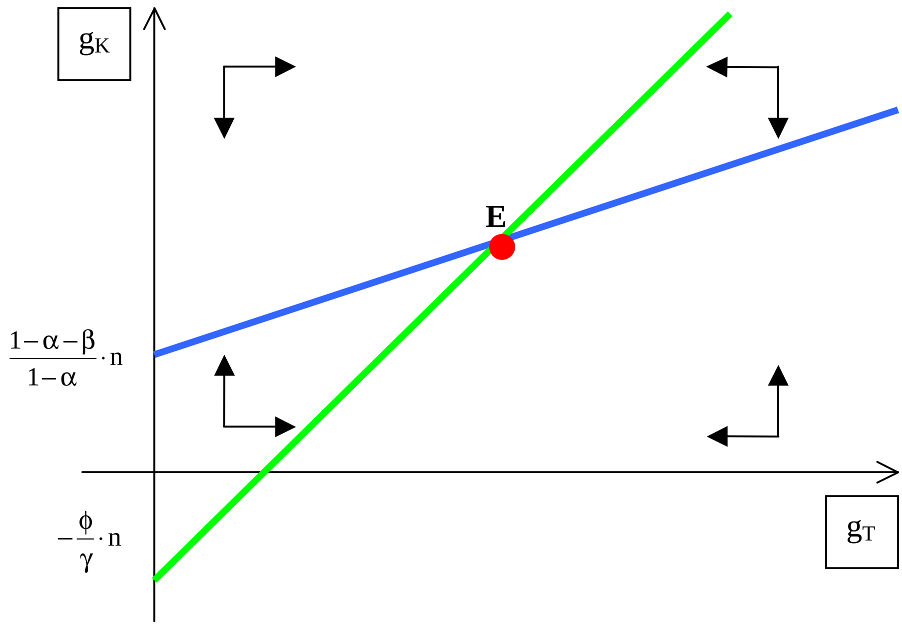
From the production function (1) we know that the combined changes in the growth rates of T and K will eventually determine how output per worker evolves. Changes in factors that affect the growth rates of T and K will only have a temporary effect when a "balanced growth path" exists. That is, when a unique and stable cross-point between the two 0 loci can be derived.

Obviously, for such a cross-point to exist, the slope of the second locus should be steeper than the one for the first locus. Thus:

$$(9) \qquad \frac{\beta}{1-\alpha} < \frac{1-\delta}{\gamma}$$

Can we somehow reasonably conjecture this condition to hold? To answer this, note that β denotes the degree of diminishing returns to ICT capital in the final goods producing sector, α the degree of diminishing returns to physical capital in that sector, δ the extent of diminishing returns to ICT capital in the ICT sector, and γ the one for physical capital in the ICT sector. Thus, the condition in (9) holds when production of final goods takes place with a relatively low degree of diminishing returns to software, but with a relatively high degree of diminishing returns to "other" physical capital than the one observed in the intermediary goods sector. Perhaps these assumptions are not too far off from what is actually happening in the real world. Graphic design packages are, for instance, are much more rapidly updated or replaced in software houses than in more traditional sectors.

In that case, we can combine the above 0-loci to find out more about the behavior of the economy:



The figure shows that, regardless where the economy begins, it will always converge towards point E. Due to condition (9), both g_K and g_T – and thus the endogenous rate of growth of output per worker – are positive and constant in that equilibrium, where:

$$g_K^* = \frac{(1-\alpha-\beta)(1-\delta)+\beta\phi}{(1-\alpha)(1-\delta)-\beta\gamma}\cdot n \quad \text{and} \quad g_T^* = \left[\gamma\cdot\frac{(1-\alpha-\beta)(1-\delta)+\beta\phi}{(1-\alpha)(1-\delta)-\beta\gamma}+\phi\right]\cdot\frac{n}{1-\delta}$$

A non-zero endogenous growth of output per worker exists when the labor force growth is positive. Under constant returns to scale in the software sector (when $\phi=1-\delta-\gamma$) the expressions reduce to $g_K^*=g_T^*=n$ and $g_{Y/L}$ becomes eventually zero. Finally, note that when the 0-loci do not cross (that is, when condition (9) does not hold), the growth path will be an unrealistically explosive one when population growth exceeds zero.

Consequently, any change in the fraction of capital or workers employed in the sectors, or an exogenous productivity shock in the software-producing sector, will only result in a *temporary* change in the growth rate of labor productivity. The speed with which the economy moves back towards the equilibrium depends on the investment rate, the relative allocation of the production factors across the sectors, and the cross-sectional differences in the degree to which there are decreasing returns to accumulating them (see equations (5) and (7)).

Thus, in the absence of network externalities from consuming new technology, a simple 2-sector model reveals that it is not very clear why the production of software – or ICT in general for that matter – would be an engine of long-run growth, even if it would be produced under increasing returns to scale. Long-run growth in this framework is determined by population growth, a result that has been well established in earlier “knowledge driven” growth models.

Let us now take this result one step further. In the remainder of this section we explicitly rule out software as an engine of long run growth by presuming that a steady state exists. We then investigate whether definitional changes such as those mentioned in the introduction have a permanent impact on measured growth.

2.2 Software production from intermediary input to gross fixed capital formation

Let us therefore turn back to our model, and suppose for a moment that one would no longer account software expenditures as intermediary input, but as gross fixed capital formation by the final goods producing sector. In other words, the national accounts switch from reporting $GDP=Y\equiv C+I$ to $GDP'=Y+dT/dt\equiv C+(I+dT/dt)$. This is clearly what the latest revisions of the system of national accounts were all about. Thus, in terms of our model, the perceived GDP is then no longer Y, but it is taken to be

(10)
$$\begin{aligned} Y_{new_t} &= Y_{old_t} + \frac{dT}{dt} \\ &= Y_{old_t} \cdot \left(1 + \frac{dT/dt}{Y_{old_t}}\right) \end{aligned}$$

Likewise, the investment share is no longer the constant s, but becomes:

(11)
$$s_{new_t} = \frac{s \cdot Y_{old_t} + dT_t/dt}{Y_{old_t} + dT_t/dt}$$

Obviously, this change in the accounting principles does not alter company accounts – actual output produced by the final goods sector, as well as the price level remain unaffected. Also, consumption in the two accounting systems should still report the same amount:

(12) $$(1-s_{new})\cdot Y_{new} = (1-s)\cdot Y_{old}\,,$$

so that the new and equilibrating marginal consumption quote will equal

(13) $$1-s_{new} = (1-s)\cdot \frac{Y_{old}}{Y_{new}}$$

The definitional change would not have much of an importance for economic analysts if the changes would simply result in an intercept shift of GDP. [3] However, taking logarithms and time derivatives for equation (10), and using a Taylor expansion to approximate ln(1+x) by x, shows that only a level effect is doubtful:

(14) $$\begin{aligned} g_{Y_{new}} &= \frac{d\ln[Y_{new}]}{dt} = g_{Y_{old}} + \frac{d}{dt}\left[\frac{dT/dt}{Y_{old}}\right] \\ &= g_{Y_{old}} + \left[\frac{1}{Y_{old}}\frac{d}{dt}(dT/dt) - \frac{dT/dt}{Y_{old}}\cdot g_{Y_{old}}\right] \\ &= g_{Y_{old}} + \frac{dT/dt}{Y_{old}}\left[g_{\frac{dT}{dt}} - g_{Y_{old}}\right] \end{aligned}$$

Put differently:

(15) $$g_{GDP_{new}} = g_{GDP_{old}} + \frac{\text{Softw.exp}}{GDP_{old}}\cdot\left[g_{\text{Softw.exp.}} - g_{GDP_{old}}\right]$$

From these derivations it becomes clear that the definitional changes merely shifted up the reported investment share – seemingly creating an "investment boom" that results in an apparent growth bonus. This bonus depends on both the size of the software sector and the growth of its output compared to the evolutions in the old GDP.

The bonus that results from measuring the economy differently may be quite important. Estimates show that current dollar investments for software by businesses and government increased importantly 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.

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[3] Like e.g. the 1996 changes in the American NIPAs (recognition of government investment as gross fisxed capital formation)

Table 1. 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.

2.3 Simulations

Do definitions matter that much in the end? To answer this question, simulations may be helpful. More precisely, we will plug the changed accounting principles into the model we developed earlier. That is, we will look at the predicted pattern for actual and measured labor productivity growth under the mentioned modification of the national accounts. The key question then is whether a permanent upward shift of labor productivity growth can be expected. In the section 3 we will focus more specifically on the pattern for TFP growth.

For our simulations we use the following initial values:

Table 2. Initial values

Parameter or variable	Value	Referring to
α	0.333	final goods sector
β	0.333	final goods sector
ϕ	0.333	software sector
δ	0.800	software sector
γ	0.025	software sector
A_T	0.500	software sector
a_L	0.250	weight for labor input
a_K	0.250	weight for capital input
a_T	0.650	weight for software input
n	0.010	growth rate of work force
s	0.150	investment share
implied returns to reproduced factors	1.490	
implied long-run growth of output per worker	1.3%	

Except for α and (1-α-β), which should be around 1/3 and 2/3 reflecting the remuneration for respectively capital and labor as a share of GDP, these parameters are admittedly chosen ad hoc to reinforce condition (9). The values imply that the returns to reproduced factors are 1.49, and the steady state growth rate of income per worker is exactly 1.3 %.

In order to investigate the impact of the change in accounting principles, we run four simulations: a) a change in the national accounts when the economy is in its steady state, without any other shock, b) an autonomous productivity shock (A_T) in the ICT sector, c) a productivity shock that goes together with a higher share of labor and capital in the ICT sector, and d) a productivity shock that goes together with a higher share of capital and IT-equipment in the ICT sector, with both substituting for labor.

The results of these simulations are reported in Figures 1 through 4, and the details of the parameters are described above each chart.

<Figures 1 through 4 here>

The messages that we learn from these exercises are threefold. Firstly, we observe that with software expenditures being accounted as investment, the long-run outcome is indeed a shift in the reported growth rate. Note that this shift is not related whatsoever to higher real economic activity. From equation (15) we know that the magnitude of the statistical bonus mainly depends on the relative size of the software sector. That is: the “new economy” effect is driven by software production – a result that is in line with the work by Gordon (1999).

Secondly, in combination with the definitional adjustments, any shock to the software sector will lead towards a “new economy” result (that is: a boost in labor productivity growth) for only as long as the shock lasts. Thereafter, the economy abruptly falls back to slightly above its new steady state growth rate, which differs by roughly a constant of the “old” one. This phenomenon is largely driven by the fact that the reported investment share has become sensitive to the behavior of the intermediary goods sector.

Thirdly, changes in the economy that would have lead to the conclusion of a slow down, or even recession of the economy may become swamped by the growth bonus. Thus, the cycle will appear to be larger compared to what would have been reported under the old system of national accounts.

Obviously, these are only simulations. In order to find out the final effect on TFP growth – the crucial factor to judge a new economy – a logical step would be to calibrate the model with actual data. This procedure, however, would expose the whole exercise to criticisms that unavoidably trace back to the assumptions of the model. Therefore we opted to set up a growth accounting framework with and without definitional changes. After all, this is still how TFP is computed by statistical offices such as the Bureau of Labor Statistics, or by the European Commission.

3 Do modifications in the accounting principles affect measured TFP growth? Growth accounting evidence

Let us thus 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 of the change in TFP growth is attributable to measurement issues?

In order to investigate this, recall that TFP growth is typically computed in a neoclassical framework. 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?

In order to detangle the impact of these changes we proceed as follows. Let Y_{old} denote real GDP and K_{old} the nominal capital stock – i.e. the sum of non-IT and IT equipment – *before* software outlays were added as investment. Clearly,

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

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 current production function is:

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

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

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

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)≈x, yields an expression for the growth rate of labour productivity (g_y):

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

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

(20) $$\begin{aligned} g_{y_{new}} &\equiv g_{y_{old}} + \frac{S/p_S}{Y_{old}} \cdot \left(g_S - g_{p_S} - g_{Y_{old}}\right) \\ &= g_{A_{new}} + \alpha \cdot \left(g_{k_{old}} - g_{p_K}\right) + \alpha \cdot \frac{S/p_S}{K_{old}/p_K} \cdot \left(g_S - g_{p_S} - g_{K_{old}} + g_{p_K}\right) \end{aligned}$$

It becomes visible that the definitional changes affect both TFP growth and capital deepening. Table 3 summarizes the impacts.

Table 3: TFP and capital deepening before and after the definitional changes

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

Introducing hedonics has clearly an impact on both capital deepening and TFP growth. Both factors are also lifted to a higher level than what was observed prior to accounting software outlays as investment.

Just how large is the bonus? Table 4 reports in this respect the necessary figures for the computations. They are taken from Parker, 2000, Jorgenson and Stiroh, 2000, Eurostat for the ESA79 definitions, and the European IT Observatory. From the last source we were also able to compute an average price index for IT equipment, and hence a weighted price index for total physical 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.

Table 4: data

	S bn USD nominal	**g_S** % nominal	**Y_{old}** bn USD real, p95	**g_{Yold}** % real, p95	**K_{old}** bn USD nominal	**g_{Kold}** % 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	**p_{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%		
1997	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:

Table 5: theoretical gains of definitional changes

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

Table 6: the real acceleration in the US economy

	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:

Table 7: comparing like with like

	Capital deepening					
	Official data			**Common definition**		
	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					
	Official data			**Common definition**		
	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					
	Official data			**Common definition**		
	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

The acceleration in US TFP growth drops to 0.24 as opposed to 0.82, and compares to a virtual status quo in Europe. Clearly, the trend in American TFP and labor productivity growth remains positive but far less important than the official data would suggest.

4 Conclusion

In this paper we started off from the observation that official data reveal an extraordinary step in US total factor productivity growth (TFP) in 1996, which led to important gains in labor productivity growth in the second half of the 1990s. Apparently, 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.

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 labor 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).

In this paper we have tried to show that re-shuffling software from intermediate consumption to investment in the national accounts may indeed result in a measured growth bonus. We did this in three ways: 1) in an analytical way by looking at a suitable 2-sector endogenous growth model, 2) by simulating the impact of definitional changes in the model, both with and without shocks to the economy, and 3) by setting up a growth accounting exercise with and without definitional changes.

The emerging patterns reinforce each other and suggest that under the previous accounting principle – in which software expenditures were not treated as investment – economists would have been far less impressed by the US economic performance in the 1990s. The analysis reveals that higher measured American TFP growth in the late 1990s was for about 50% due to statistical modifications that are not yet fully operational in Europe

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 labor productivity growth in the US remains, however, positive.

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6 Figures

Figure 1: Baseline simulation.
The economy is in the steady state. National accounts change in period 5.

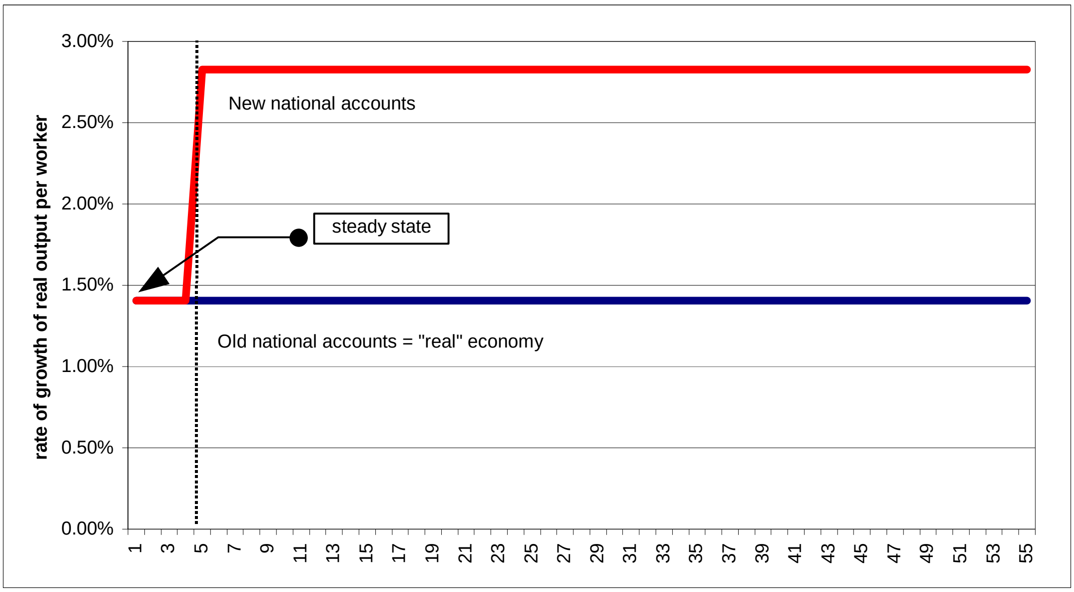

Figure 2: Simulation of a productivity shock in the software sector
The economy is in the steady state. National accounts change in period 5. At the same time there is a productivity shock in the software sector: A_T grows at 1 percent a year from 0.50 to 0.55 over a period of 10 years.

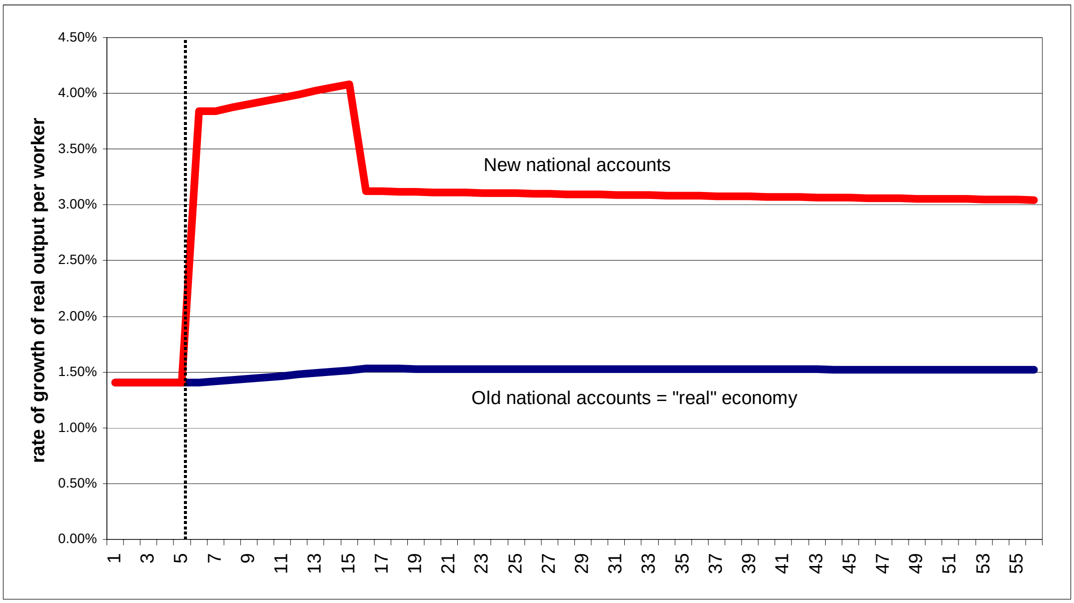

Figure 3: An additional shift of production factors into the software sector

The economy is in the steady state. National accounts change in period 5. At the same time there is a productivity shock in the software sector. Over a period of 10 years, A_T grows at 1 percent a year (from 0.50 to 0.55), while a_K and a_L grow at 0.96 percent a year (from 25 % to 27.5 %)

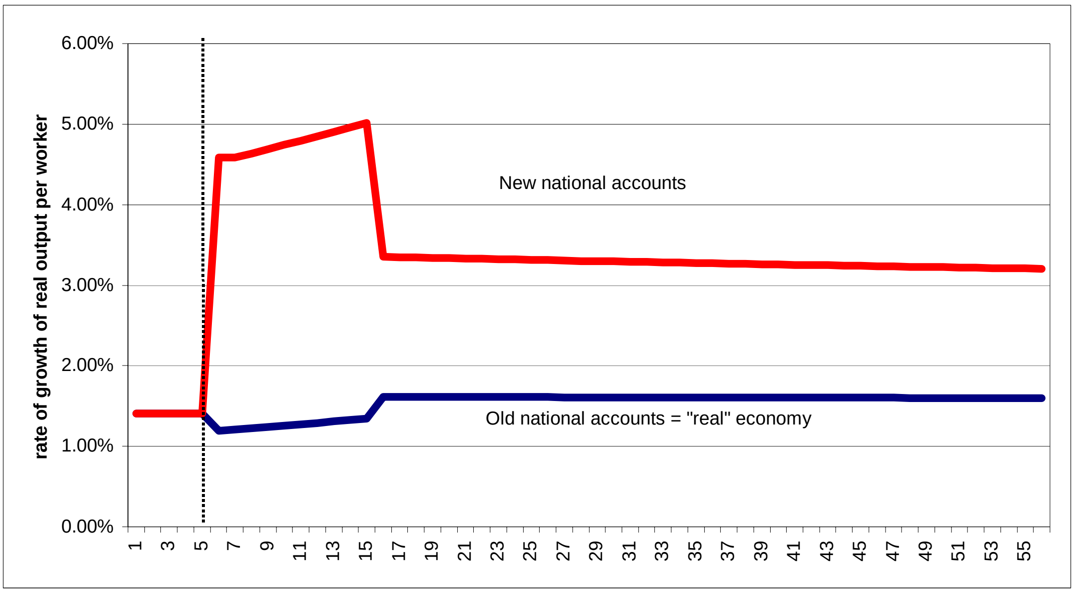

Figure 4: Software sector becomes less labor intensive

The economy is in the steady state. National accounts change in period 5. At the same time there is a productivity shock in the software sector. Over a period of 10 years, A_T grows at 1 percent a year (from 0.5 to 0.55). While a_K grows at 0.96 percent a year (from 25 % to 27.5 %), a_L reduces at 0.96 percent a year (from 25 % to 22.75 %), and is being replaced by software. Consequently, a_T gradually increases at 0.96 percent a year (from 65 % to 71.5%).