Total factor productivity : Lessons from the past and directions for the future

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Total Factor Productivity

Lessons from the Past and Directions for the Future

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[1] This brief paper is based on earlier work, including Timmer, Inklaar, O'Mahony and van Ark (2010), van Ark et al. (2011, 2013) and van Ark (1999, 2014). Various updates to the measures have been included in this paper, which are the sole responsibility of the author. I am especially to Abdul Erumban and Kirsten Jäger for updates of the growth accounting estimates presented in this paper.

1. The Most Famous Residual in Economics

It has one of the most celebrated residuals in economic science: Total Factor Productivity, the growth in output after taking into account the growth contributions from inputs. Many academic articles, reviews and even books have been dedicated to the topic; not to speak of the millions of hours that academics spent on conceptualizing, measuring and interpreting TFP. Also, policy makers are intrigued by the TFP concept and have spent much effort to understand how policies might positively impact on a country's total factor productivity.

Why are we so obsessed by the total factor productivity (TFP) residual?[2] The answer is simple: productivity is the only sustainable source of long-term economic growth. Without productivity, an economy will slowly grind to a halt. It is the only growth factor that does not suffer from diminishing returns as homogeneous inputs typically do. TFP growth also represents so-called spillovers or externalities, which arise from returns on inputs that go beyond those that can be internalized by the investor. Those spillovers mostly result from societal benefits that arise from technological progress and innovation. TFP is therefore not only the business of corporations, but also an area of intense interest to public policy makers.

The impact of productivity on economic growth is very important, even though its growth contributions sometimes look small compared to, for example, labour or investment as growth drivers. However, TFP growth is a compounding measure, which means that small annual improvements do add up over longer periods of time. This simple truth is often underappreciated by policymakers and business leaders who feel under pressure for quick results. In the same way that TFP growth can sustain long-term growth, a long-term slowdown in TFP causes a gradual erosion of the economy's ability to generate growth or prevent a decline. The slowdown in TFP growth is therefore a matter of major concern in several mature economies, notably in Europe but recently also in the United States and even in several emerging market economies.

This short overview paper begins with a brief review of some of the key notions and issues with regard to the measurement and use of total factor productivity metrics (Section 2). We then zoom in on some empirical applications, which include the latest updates of the TFP slowdown in Europe (Section 3), newly measured TFP spillovers from ICT network effects (Section 4), and the impact of intangibles investments on TFP (Section 5). The paper concludes with a few observations with regard to policy making aimed at reviving growth through productivity in Europe (Section 6).

[2] For a review of the early history of the TFP residual, see Griliches (1996). Other useful reviews on the history of productivity are Nadiri (1970), Griliches (1998) and Hulten (2001; 2010).

2. A Bird's Eye View on Total Factor Productivity

Productivity measures the level or growth of output produced by companies, sectors, and countries relative to the inputs required to produce that output. It therefore provides a simple but powerful indicator of economic efficiency. Companies seldom measure productivity directly. They usually use shareholder return, total business return, or economic value added, measures that put greater emphasis on the financial component of business performance. Even when measuring productivity, businesses may look at sales per person or, on a project basis, physical output (tonnage or volume) per person hour or per machine hour.

For the economy as a whole, labour productivity is the most widely used metric. It measures output per employed worker. If working hours can also be measured, labour productivity can be measured on a per hour basis. Labour productivity is strongly related to measures of living standards such as, for example, per capita income — the higher the relative level of productivity, the higher the per capita income, and the greater the chance for economic and wealth expansion. Moreover, labour productivity's relationship to economic growth can be easily demonstrated, since the change in labour productivity multiplied by the rise (or decline) in total hours worked in the economy equals the growth in national output (gross domestic product, value added or sectoral gross output). The main shortcoming of the labour productivity metric, however, is that it cannot distinguish between the gains from more equipment per worker and the gains from more efficiency or better technology use per worker.

For understanding how productivity contributes to economic growth, it is therefore advisable to use a somewhat more sophisticated metric. Total factor productivity (TFP; or multi factor productivity) growth is derived by calculating the growth in domestic output unexplained by the growth in all inputs in the production process, not just labor.[3] In practice, TFP mostly refers to the combined efficiency of labour inputs and capital inputs relative to the growth in GDP or value added. The measurement of different types of human capital (age, gender and skill level) and physical capital (machinery, transport equipment, ICT, etc.) allows for the identification of quality changes in the factor inputs due to shifts in the composition to high performing assets. In the case that measures of intermediate inputs, such as energy, materials and services inputs, are available, TFP can also be related to gross output.[4]

[3] The terms Total Factor Productivity and Multi Factor Productivity can be used interchangeably. The former is mostly used in the academic literature, even though Multi Factor Productivity correctly recognizes that every productivity measure starts with assumptions on which factor and non-factor inputs to include.

[4] The term KLEMS which is often used for empirical growth accounting studies including TFP, stems from the five inputs, capital (K), labour (L), energy (E), materials (M) and services inputs (S). See section 3.

Under strict neo-classical assumptions, TFP growth measures disembodied technological change, as exemplified in its original application by Solow and therefore often referred to as the "Solow Residual" (Solow, 1957). But in practice measured TFP can include a range of other effects beyond technological change. For one thing, TFP includes the growth impact of unmeasured inputs, such as the expenses on certain "soft" or "intangible" inputs such as R&D, software, human capital skills' development, and branding and marketing, among others. When those inputs are not explicitly measured as inputs, their returns will entirely turn up in the TFP measure (see Section 5).

As several of the neo-classical assumptions of perfectly functioning markets, the equalization of marginal cost and product, and Hicks neutral technical progress (which assumes that technical progress does not the ratio of labor to capital in the production function) do not hold up in reality, measures of TFP measure can also be influenced by imperfect competition, increasing returns to scale, and any externalities related to investment. For example, there often are obstacles to the free mobility of labor, land or physical and financial capital. Distortions in resource allocation are all almost always attributable to policy or institutional deficiencies. Structural reform can rectify such deficiencies – strengthening TFP growth – but it is never easy, or painless, and thus tends to be both politically and often socially unpopular.

When measured at the sector or industry level, TFP includes the effects of reallocation of market shares across firms, which is an important area for competition policy. Finally, the TFP residual also absorbs measurement errors, as they arise from measuring the outputs and inputs in the productivity process.

Total factor productivity has also been referred to as "real" cost reductions (output quantities divided by input quantities), which may be contrasted with "nominal" productivity measures, as often used by companies, that simply look at cost over sales or margins. For example, an increase in output value (adjusted for inflation) relative to the rise in the number of workers is a real cost reduction. In contrast, a cut in wages without a change in the real number of workers is a nominal efficiency gain but does not represent a productivity increase (Harberger, 1998).

At macro-level total factor productivity, is best analyzed and measured in a consistent growth accounting framework, which can be developed in parallel to a national accounts framework, allowing for an assessment of the relative importance of labour, capital and intermediate inputs to growth, and for measures of total factor productivity (TFP) growth. Following early attempts by Tinbergen (1942) and Solow (1957), growth accounting started to really take off during the 1960s with the work of various scholars, including Kendrick (1961), Denison (1962) and Jorgenson and Griliches (1967). Important international studies were undertaken by Denison (1967), Maddison (1972, 1982, 1991) and Jorgenson (1995).

An important strand in the growth accounting tradition has focused in more detail on the opening up of the "black box", i.e. the residual, that remains after allowing for the contribution of the quantity and quality of labour, capital and land to growth. In the early days of growth accounting, the residual was baptized a "measure of our ignorance" (Abramovitz, 1956). The work by Denison (1962, 1967) has been of fundamental importance in understanding the role of economies of scale, allocation of resources, advances in knowledge, and the effects of irregularities in demand. Maddison (1972, 1982, 1991) has continued to expand international comparisons of growth accounting by quantifying the contributions of augmented inputs, foreign trade effects, catch-up effects, structural effects and economies of scale to output growth. Maddison identified these factors as typical "proximate" sources of growth as they contribute directly to changes in output growth. However, he also emphasized the importance of "ultimate" sources of growth which are related to the political-institutional environment, and he stressed the importance of historical events.

By taking into account the wide variety of factors that can impact on total factor productivity, one can construct an extended growth accounting framework. The top panel in Chart 1 represents the variables from the traditional KLEMS growth accounting framework, as laid out by Jorgenson and associates (1987), and later implemented for Europe by Timmer et al. (2010). The bottom panel of the chart identifies some of the key factor impacting on the TFP residual, some of which will be studied in more detail in the next two sections: intangibles and network effects from technological change in ICT.

3. The Productivity Slowdown in Europe

While Europe struggles to recover from crisis and works to bring down high unemployment rates, the real challenge facing policymakers and citizens alike is the search for a path to sustainable growth in the medium and long terms. Before the onset of the economic and financial crisis in 2008, the EU-28 grew at a healthy annual average of 2.6%. However, if one adds the crisis years to the calculation, average growth from 1995 to 2013 was only 1.8 %.[5] The latest projections by The Conference Board shows Europe growing at only at 1.4% in the post-crisis period (2014-2019) – almost half of its pre-crisis average and well below the equivalent forecast (2.4%) for the United States. These estimates are based on prevailing trends in the underlying economies' principal sources of growth – labour, capital and productivity.[6]

When looking at the decomposition of sources of economic growth in Europe, it turns out that productivity is the Achilles' heel in Europe's growth picture. Labour productivity growth has been on the decline in Europe for nearly three decades. Some of the decline in the 1970s and

[5] Updated from van Ark et al. (2013).
[6] See Erumban et al. (2013) and the The Conference Board Global Economic Outlook 2014 (http://www.conference-board.org/data/globaloutlook/)

1980s was due to the fact that the historical "catch up" effect from higher productivity in the US began to peter out. Despite some stabilisation in the 1990s, productivity growth slowed further in the 2000s. While the most recent recessions brought labour productivity growth down further, from a longer-term perspective it just shows up as a continuation of the trend. There is also evidence emerging that the crisis, so far, as not helped to accelerate the reallocation of resources between sectors and firms – which has been typical of previous post-recession periods.[7]

Using the growth accounting methodology, Tables 1a to 1c decompose the growth of aggregate GDP into the contributions of labour, capital and TFP for three sub-periods, 1995-2002, 2003-2007 and 2008-2013. Amongst those three sources of growth capital growth, split between ICT and non-ICT capital, was the main driver of growth in the aggregate EU estimates during all three sub-periods. From 1995-2002, non-ICT capital (machinery, equipment and structures), contributed 0.7 percentage points to growth, with an additional contribution of 0.6 percentage points ICT capital (computers, software, and databases). During the boom period, 2003-2007, the ICT capital contribution somewhat dropped off to 0.4 percentage points. But even during the crisis period, 2008-2013, capital continued to contribute 0.8 percentage point to growth, roughly divided equally between ICT and non-ICT capital.

While labour growth was the main driver of faster growth during the boom-period 2003-2007, it dropped sharply during the crisis period. The main villain among the growth detractors during the crisis period, however, was total factor productivity which fell at a dramatic 0.7 percent in the EU-27 from 2008-2013. Virtually no European economy exhibited positive TFP growth during the crisis period.

However, the crisis should not be seen as the only or even the main cause of the productivity slowdown. In fact the slowdown started well before the crisis. This can be most clearly observed when looking at a breakdown of growth accounts between three major sectors of the economy: goods production, market services and non-market services.[8] Table 2 presents the sector-level TFP estimates for eight major European economies (Austria, Finland, France, Germany, Italy, the Netherlands, Spain and the United Kingdom). In the goods sector, average

[7] See, for example, Riley et al. (2014).

[8] Those estimates are obtained from the EUKLEMS database (www.euklems.net) with updates to 2011, where not available, by The Conference Board. Goods production includes agriculture, mining and manufacturing. Market services include wholesale and retail trade, transportation and warehousing, etc. Non-market services include community, personal and social services, education, health care and public administration, and real estate services Measurement problems with regard to output in non-market services are large and the output and productivity estimates should therefore be interpreted with caution. Real estate activities are also included with non-market services, as the output measure includes imputed rents on owner-occupied dwellings, making the interpretation of the productivity measure problematic.

annual TFP growth for eight economies was 1.5% from 1996-2002. It went up to 2.8% during the boom years from 2003-2007, and then slowed to 0.2% during the crisis. With Finland as a clear outlier at the high end, at least until 2007 driven by strong productivity gains from its ICT industry, Italy and Spain both showed very slow TFP growth in the goods throughout the period.

TFP growth was much weaker in market services than in goods production, at 0.6% from 1996-2002 for the eight economies together, slowing to 0.3% from 2003-2007 and turning negative at -1.2% during the crisis. The differences in TFP growth between countries were less in market services than in good production, although Italy and Spain both performed at the lower end. Timmer et al. (2010) have documented the weakness in Europe's services productivity in quite some detail. While there is evidence of lower ICT investment in Europe's services sector relative to, for example, the United States – albeit with large differences across economies – factors related to market structure, competition and lack of a European single market for services were also playing a role in Europe's weak productivity performance in market services.

In non-market services, TFP growth was zero or negative in all eight European economies for three sub-periods. While the measurement of real output in non-market services is fraught with problems, which are only slowly being resolved, it is important to understand the dynamics of change in the sector, which accounts for up to 30 per cent of employment in most European economies. Non-market services typically show weak productivity growth, as the Baumol "cost-disease" hypothesis in services applies mostly to non-market services. However, the potential for technology applications, as attested by the relatively strong continued increases in ICT capital, and presumed cost savings in non-market services remains strong.

Overall, the sectoral growth accounts show considerable declines in TFP growth across the board between 1995 and 2013, despite a brief improvement in the good sector from 2003-2007. Slow productivity growth in services partly results from slower adjustments and misallocations of inputs, which may point to the need for continued structural reforms in labour and product markets. However, there are many indications that the failure to effectively adopt new technologies and innovation over a significant period of time is an important factor too. So while not downplaying the importance of external market development and market structure, the remainder of this paper will focus on the role of technology and innovation, in particular the slow ICT pickup in Europe, and weak investment trends in intangible assets.

4. New Futures for Productivity Research: Externalities of ICT[9]

One of the biggest current opportunities to accelerate productivity growth is through the on-going digitalisation of the European economy. The digitalisation of advanced economies in Europe and elsewhere has a long history, but the effects on economic growth have only become most visible in the past two decades. From the mid-1990s to the mid-2000s, most of the economy's digitalisation was reflected in rising labour productivity resulting from larger investment in ICT hardware and software. In the past decade, however, the contribution of ICT has become more widespread as well as more complex when it comes to its impact on productivity. Especially the combined rise of broadband and the production of evermore powerful mobile devices are among the biggest enablers of productivity gains from the economy's digitalisation. In particular, the returns-to-scale effect – also known as Metcalfe's Law, which states that the value of a network increases with the square of the number of users of the network – means that digitalisation carries a disproportionally large benefit to growth and particularly to total factor productivity.

Like the rise of other general purpose technologies which affected the long-term growth performance of entire economies, such as the steam engine or the electric grid, ICT typically impacts the economy in three different ways over a prolonged period of time:

1. *A technology effect through the ICT-producing sector.* Firms in the tech-producing sector often experience very strong productivity gains. Before the onset of the crisis, from 2001 to 2007, total factor productivity in ICT and other information services was on average 1.5% per year for the same sample of eight major EU economies as above, 4.5% in telecommunication services, and 4.8% for the producers of electrical and optical equipment. Even though these industries only represent a small part of the economy (about 8% of total GDP in Europe), they accounted for more than 40% (0.3%) of aggregate total factor productivity growth (0.7%) in the market sector of these eight economies, the total factor productivity contribution of the three ICT sectors remained positive at a modest 0.16% from 2008 to 2011.

2. *An investment effect from ICT-using industries through capital deepening.* Investment in digital technology takes place through the spending on ICT and telecom hardware, software, networks, databases, and user platforms across the economy. As shown earlier, the investment effects from ICT positively affected value added growth before the 2008-2009 crisis, and these effects have remained positive throughout the crisis period since 2008. In particular, since 2011 when non-ICT investment in Europe had begun to severely slow, ICT capital remained strong and contributed as much to growth as in the early 2000s. While positive for output and labour productivity growth, ICT investment does not necessarily lead to greater efficiency in the

[9] This section is largely based on van Ark (2014), with data and estimates obtained from Corrado and Jäger (2014).

economy, as measured by total factor productivity growth. Investment booms in new technology can, temporarily, cause a slowdown or even a decline in efficiency. Changing degrees of utilisation of the new capital installed, especially after the creation of new networks, can impact significantly on productivity.

3. *Network effects on productivity from ICT use in non-ICT sectors.* The productivity effects of using new technology are not easy to identify or quantify, and the traditional standard growth accounts do not suffice to disentangle which part of productivity growth can be linked to so-called network externalities. Network externalities come in two parts: 1) a return-to-scale effect, which directly relates to Metcalfe's law; and 2) the productivity effects from innovative adaptations from the use of, for example, the Internet and wireless technologies. The productivity impact of the two network effects, which was obtained from an econometric analysis for eight European countries, shows these effects to be quite low. For example, between 2001 and 2007, the returns-to-scale (Metcalfe) effect accounted for as little as 0.16% of total factor productivity growth in the eight countries. During the 2008-2011 period, the returns-to-scale effect detracted 0.3% of total factor productivity growth because of the contraction in economic activity during that time. The effect of innovative adaptation on total factor productivity growth – at less than 0.1% throughout the 2001-2011 period – is even smaller than returns to scale but more sustainable. Together, the returns-to-scale and innovative adaptation equaled about one-third of overall TFP growth in the market sector in the eight EU countries analysed.

Table 3 shows that the combined impacts of ICT production, investment and use accounted for about one percentage point of output growth in the eight European economies from 2001 to 2007, which is substantial given that the overall market sector output growth rate of just over 2%. Close to half of the ICT effect comes from investment and the other two-quarters from productivity of ICT producers and ICT users. While the productivity contribution from ICT producers and ICT capital was largely sustained since the onset of the crisis, especially the returns-of-scale part of total factor productivity by the non-ICT sector contracted sharply, bringing the overall contribution of ICT to output growth in the 2008-2011 period to 0.1%, down from 1% in the 2001-2007 period.

This analysis makes clear that the key challenge for accelerating productivity growth through digitalisation is not solely coming from the ICT producers but also, and perhaps primarily, from the impact of widespread use of scalable (digital) platforms as a business model in organisations more generally. The sustainable effect on productivity growth will therefore need to come from stronger network effects through businesses and other organisations connecting to each other (and to the consumer) more effectively (the return-to-scale effect) and through

picking up on the latest applications in digitalization of their business models (the adaptation effect).

5. New Futures for Productivity Research: Expanding Investment to Intangible Assets

It is important that the direct impact of technological progress on productivity and its indirect productivity effect through the adoption of those technologies across the economy are not considered in isolation from a broader concept of investment beyond labour and capital. Incorporating non-technological innovations (design, financial innovations), workforce training, improvements in organizational structures, marketing and branding, and – importantly – the creation of databases and other digital systems as part of an economy's creation of capital shows that digitalization does not happen on its own. Traditionally the expenses on such intangibles have not been capitalized in the national accounts (nor on company balance sheets, for that matter). However, recent work by Corrado, Hulten and Sichel (2005, 2006) has made the case for capitalization of intangible assets.

On average, Europe has much lower investment intensity in intangibles than the US. The share of all measured intangible investment has increased by just over one percentage point to 6.7% in 2010 for an average of 14 European countries, up from 5.6% of GDP in 1995, making it just over half of the share of intangibles in US GDP (Table 4). The US saw sharper increases than Europe in computerized information itself, but also in organizational capital. Strikingly, however, while most European countries retained their intangibles during the recession, at least relative to GDP, the US lost almost a full percentage point in 2009 as a result of the recession.

ICT and intangible assets are connected in many ways. Some ICT assets, such as software and databases, are themselves classified as an intangible asset. ICT can facilitate the deployment of other intangible assets and enable innovation throughout the economy, such as the re-organisation and streamlining of existing business processes, for example through order tracking, inventory control, accounting services and the tracking of product delivery. At the same time, capital deepening in intangible assets provides the foundation for ICT to impact productivity. Without intangible investments, productivity improvements from technology progress and innovation will be minimal and a strategy towards digitalisation of the economy will quickly run into diminishing returns. For example, the internal organisation of a firm plays a role in its ability to use ICT more efficiently, in particular through the managerial and other organisational structures (Brynjolfsson and Hitt, 2000; van Reenen et al., 2010).

Going beyond complementarities between ICT and intangibles, Chart 2 suggests that there is a strong relationship between intangible capital deepening (excluding ICT) and total factor productivity growth, which is consistent with the possibility of total factor productivity

spillovers from intangible investments beyond GDP. More extensive regression estimates suggest this to be the case (Corrado et al., 2013a). This result is in line with existing evidence on spillover effects from R&D, but the extension to other assets suggests than many intangible capital assets have public-good characteristics. Also recent work on the relationship between product innovation measures shows a strong relationship to TFP (Hall, 2011). Clearly there is also much to argue against spillovers from intangibles. For example, spillovers might not occur if intangible capital is protected by intellectual property rules (copyright, trademarks, etc.) or tacit knowledge (internal knowledge of supply chain management, for example) (Corrado et al., 2013b).

Of course, even beyond a broader investment concept, other business practices may also help companies become more productive than their competitors. One line of research focused on the impact of management practices on business performance, suggests that about a quarter of cross-country and within-country TFP gaps can be accounted for by management practices. But even management competencies are at least in part the result of investment in human capital and improvement in organizational practices. For the other part, competition and governance also help account for the variation in management performance (Bloom et al. 2014).

6. From a "Measure of Our Ignorance" to a Key Performance Metric for Growth Policy

In 1956, during the early days of growth accounting and total factor productivity research, Abramovitz (1956) called total factor productivity "a measure of our ignorance". At that time, after taking account of the measurable factor inputs, we seemed not to know much more about what explained productivity growth. In Solow's 1956 model, technology was no more than a place holder as exogenous forces which were dropping like "manna from heaven" on an economy.

Almost sixty years later, we have a come a long way to better understand what total factor productivity involves. Indeed growth accounting and the measurement of TFP remain the workhorses of empirical analysis of economic growth. Despite inherent theoretical constraints with regard to the notion of TFP, there now seems wide acceptance that the assumptions of constant returns to scale, marginal cost pricing, and factor-neutral technical change can be largely overcome in empirical analysis. Especially the more detailed adjustment for quality change in capital (and labour) as a result of shifts in asset composition has helped to shrink the residual. The recent broadening of the investment concept to intangibles has further reduced TFP growth, to the extent that the returns on those investments can be captured by the investors. However, it has also been shown that the impact of new technologies, like ICT, in combination with other intangibles shows the existence of spillovers and complementarities, which in fact help boost TFP growth.

The recent analysis also clearly demonstrates that the concept of "extended" growth accounting and econometric approaches to analyze total factor productivity are not competitors (as sometimes assumed by theoretical purists), but tools that are complementary for any empirical growth economist. The new avenues for research described in sections 4 and 5 are still in their infancy, and the implications for growth accounting, national accounting and, as a consequence, economic policy making, will be substantial. Indeed, the recent inclusion of Research and Development as an asset in the national accounts, is only a first step on the way towards accounting for the key assets in a knowledge economy.

The implications of these new research avenues for policy making are huge, especially in current times as we are desperately looking on reviving growth around the world. In mature economies, and especially in Europe, the slowdown in total factor productivity growth is the Achilles' heel of our current growth record. If we don't understand what productivity involves, and what to do about it, we may be tempted to direct our attempts to revive growth to areas we do understand.

Much of the policy initiatives in the early days of the current economic and financial crisis have been focused on the creation of more jobs, which were lost in massive amounts during 2008/09. Whereas the United States has made significant progress in creating more jobs (even though it has failed so far to accelerate labor participation), job recovery in Europe has been mostly slow and even today unemployment rates remain highly elevated in many European economies.

More recently, policy attention has shifted to other ways of reigniting growth, especially now that it turns out we may have entered a period a long-term moderate growth, sometimes referred to a "secular stagnation" (Teulings and Baldwin, 2014). While the jury is still out on how to exactly characterize the current period of slow growth, at face value, it makes much sense to direct our attention to investment as a key policy tool to revive growth. For example, in a recent report the German Institute for Economic Research, DIW, has claimed that since the crisis a large investment gap has emerged across in Europe (DIW, 2014). The report shows a significant decline in the investment rate since the crisis, and in various sectors even since the late 1990s. It recommends to support private investment through a combination of better competition policies, tax incentives and a new EU investment fund could help accelerate investment in the EU.

But is investment the core problem? Or is it the efficiency by which capital is being used, exemplified by declining returns on investment? When looking at the decomposition of the growth accounts for the Euro Area, the combined contributions of ICT and non-ICT capital to GDP growth dropped from 1.2 %-point from 1995-2002, to 1.0 %-point from 2003-2007 and down to 0.6 %-point from 2008-2013 (Tables 1a to 1c). Strikingly the contribution of ICT capital

only dropped from 0.5 to 0.3 %-point during the first and the second period, but then stayed at 0.3 %-point even during the crisis period. In contrast, total factor productivity growth dropped from 0.6% from 1995-2002 to 0.4% from 2003-2007 and then collapsed to -0.7% during the crisis period 2008-2013.

These estimates suggest that weak investment, and related slower technological change and innovation, at best only partially account for the dismal growth performance in recent years, or even during the years before the crisis. Europe and the US could both surely use more investment in the current phase of recovery, but policymakers and business leaders should also focus on getting a higher return on the investments they make – i.e., productivity – if they want to put their countries on a long-term path to sustainable economic growth.

In this respect it is important to note that after taking account of quality adjustments to inputs, broader investment concepts and technological spillovers, there is still a TFP residual (positive or negative) that cannot be "explained away" just by looking at investment and technology. Indeed beyond technology and innovation, external forces (or "ultimate sources" of growth) such as market structure and institutions, but also European-specific factors such as the lack of a full single market in services or, more specifically, in digital markets, can play a large role.

In sum, despite its limitations and complexities, total factor productivity can serve as a key metric for growth policy far beyond the "ignorance" the concept bestowed upon us at the time of its invention sixty years ago.

References

Abramovitz, M. (1956), Resource and Output Trends in the United States since 1870, The American Economic Review, vol. 46, no. 2, pp. 5-23.

Ark, B. van (1999), "Accumulation, productivity and technology: Measurement and analysis of long term economic growth", CCSO Working Paper, 199908, CCSO Centre for Economic Research, University of Groningen (downloadable from http://ccso.eldoc.ub.rug.nl/FILES/root/1999/199908/199908.pdf).

Ark, B. van (2014), Productivity and Digitalisation in Europe: Paving the Road to Faster Growth, The Lisbon Council and The Conference Board, Brussels/New York.

Ark, B. van, G. Levanon, V. Chen, and B. Cheng (2011), Performance 2011. Productivity, Employment, and Growth in the World's Economies, Research Report R-1475-11-RR, The Conference Board, New York.

Ark, B. van, V. Chen, B. Colijn, K. Jäger, W. Overmeer and M.P. Timmer (2013), Recent Changes in Europe's Competitive Landscape and Medium-Term Perspectives: How the Sources of Demand and Supply are Shaping Up, Economic Papers 485, DG ECFIN, European Commission, April.

Bloom, N., R. Lemos, R. Sadun, D. Scur, and J. Van Reenen (2014), The New Empirical Economics of Management, NBER Working Paper No. 20102, May.

Brynjolfsson, E. and L. Hitt (2000), Beyond Computation: Information Technology, Organisational Transformation and Business Performance, Journal of Economic Perspectives, Vol. 14, No. 4.

Corrado, C., C. Hulten and D. Sichel (2005), "Measuring Capital and Technology: An Expanded Framework," NBER Chapters,in: Measuring Capital in the New Economy, National Bureau of Economic Research, Inc., pages 11-46

Corrado, C., C. Hulten and D. Sichel (2006), Intangible capital and economic growth, Finance and Economics Discussion Series, Board of Governors of the Federal Reserve System (U.S.) 2006-24, Board of Governors of the Federal Reserve System (U.S.).

Corrado, C. and K. Jäger (2014), Communication Networks, ICT and Productivity Growth in Europe, Report for Telefónica S.A., The Conference Board, New York.

Corrado, C, J. Haskel, and C. Jona-Lasinio and M. Iommi (2013a), Innovation and intangible investment in Europe, Japan, and the United States, Oxford Review of Economic Policy, Volume 29, Number 2, pp. 261–286.

Corrado, C, J. Haskel, and C. Jona-Lasinio (2013b), 'Knowledge Spillovers, ICT and Productivity Growth', available from www.intan-invest.net

Denison, E.F. (1962), The Sources of Economic Growth in the United States and the Alternatives Before Us, CED Supplementary Paper No. 13, Committee for Economic Development, New York.

Denison, E.F. (1967), Why Growth Rates Differ: Postwar Experience in Nine Western Countries, The Brookings Institutions, Washington.

DIW (2014), Economic Impulses in Europe, DIW Economic Bulletin, No. 7, Berlin

Griliches, Z. (1996), The Residual The Discovery of the Residual: A Historical Note, Journal of Economic Literature, Vol. XXXIV, September, pp. 1324–1330

Griliches, Z. (1998), R&D and Productivity: The Econometric Evidence, NBER Books, National Bureau of Economic Research.

Harberger, A.C. (1998), A Vision of the Growth Process, The American Economic Review, Vol. 88, Issue 1, March, pp. 1-32

Hulten, C. R. (2001), 'Total Factor Productivity: A Short Biography', in C. R. Hulten, E. R. Dean and M. J. Harper (eds.), New Developments in Productivity Analysis, NBER Studies in Income and Wealth, 63, University of Chicago Press, Chicago, pp. 1–47.

Hulten, C. R. (2010), 'Growth Accounting', in B. H. Hall and N. Rosenberg (eds.), Handbook of the Economics of Innovation, Elsevier North-Holland, Amsterdam.

Jorgenson, D.W. (1995), Productivity, Volume 1, Postwar U.S. Economic Growth & Volume 2, International Comparisons of Economic Growth, The MIT Press, Cambridge Mass.

Jorgenson, D.W. and Z. Griliches (1967), The Explanation of Productivity Change, Review of Economics and Statistics, July, pp. 249-283.

Jorgenson, D. W., F. M. Gollop and B. M. Fraumeni (1987), Productivity and U.S. Economic Growth, Harvard Economic Studies, Cambridge, MA.

Kendrick, J.W. (1961), Productivity Trends in the United States, Princeton University Press.

Maddison, A. (1972), Explaining Economic Growth, Banca Nazionale del Lavoro Quarterly Review, September.

Maddison, A. (1982), Phases of Capitalist Development, Oxford University Press.

Maddison, A. (1991), Dynamic Forces in Capitalist Development, Oxford University Press.

Nadiri (1970), Some Approaches to the Theory and Measurement of Total Factor Productivity: A Survey, Journal of Economic Literature, 8 (4), pp. 1137-1177.

Reenen, J. van, N. Bloom, M. Draca, T. Kretschmer and R. Sadun (2010), The Economic Impact of ICT, SMART N. 2007/0020, Final Report, Centre for Economic Performance, Report for the European Commission, Brussels.

Riley, R., C. Rosazza Bondibene and G. (2014), Productivity Dynamics in the Great Stagnation: New Evidence from UK Business, paper presented at the Royal Economic Society 2014 Annual Conference, 27 April 2014. A summary of this paper is available on Royal Economic Society website at www.res.org.uk.

Solow, R.M. (1957), Technical Change and the Aggregate Production Function, Review of Economics and Statistics, vol. 39, pp. 312-330

Teulings, C. and R. Baldwin (2014), Secular Stagnation: Facts, Causes and Cures, VoxEU, Centre for Economic Policy Research, London.

Timmer, M.P., R. C. Inklaar, M. O'Mahony and B. van Ark (2010), Economic Growth in Europe. A Comparative Industry Perspective, Cambridge University Press.

Tinbergen, J. (1942), Zur Theorie der Langfirstigen Wirtschaftsentwicklung, Weltwirtschaftliches Archiv, vol. I.

Table 1a: Growth Contributions by Supply-Side Sources of Growth, log growth, 1995-2002

Average growth of 1995-2002		From		Contributions to GDP Growth From				
	Growth rate of GDP	Hours Worked	Labour Productivity	Hours Worked	Labour compositi on	Non-ICT capital	ICT capital	Total Factor Productivity growth
	1	2	3	4	5	6	7	8
EU-27	2.6	0.6	2.0	0.4	0.3	0.7	0.6	0.7
Euro Area	2.4	0.8	1.7	0.5	0.2	0.7	0.5	0.6
EU-15	2.5	0.8	1.8	0.5	0.3	0.7	0.6	0.5
Sweden	8.5	3.4	5.2	2.0	0.4	2.2	1.0	3.0
Germany	4.7	3.4	1.3	1.9	0.4	2.4	0.0	0.1
Luxembourg	3.3	0.6	2.7	0.3	0.6	1.4	0.7	0.3
Austria	3.9	1.5	2.4	1.0	0.2	0.2	0.7	1.9
Netherlands	3.9	3.3	0.6	2.2	0.4	1.3	0.5	-0.4
Belgium	3.1	0.7	2.4	0.4	0.3	0.6	0.5	1.3
Finland	3.3	0.8	2.5	0.5	0.6	0.6	1.0	0.5
France	2.6	0.1	2.4	0.1	0.4	0.5	0.6	1.1
Spain	3.1	1.8	1.3	1.2	0.3	0.5	0.6	0.4
United Kingdom	2.3	1.4	0.9	0.9	0.3	0.8	0.5	-0.2
Ireland	2.3	1.3	1.0	0.9	0.3	0.6	0.9	-0.4
Portugal	2.3	0.2	2.1	0.1	0.4	0.7	0.5	0.5
Denmark	1.5	-0.3	1.9	-0.2	0.0	0.3	0.3	1.1
Italy	1.8	0.9	1.0	0.6	0.2	0.6	0.4	0.1
Greece	3.5	1.5	1.9	1.0	-0.1	1.3	0.7	0.5
EU-12	3.5	-0.9	4.4	-0.5	0.2	1.2	0.6	2.1
Poland	6.5	0.8	5.7	-0.4	0.3	3.0	0.0	2.1
Slovak Republic	6.6	-0.3	6.9	-0.9	0.1	1.8	0.0	3.4
Bulgaria	6.4	-1.8	8.2	-1.2	0.3	1.1	0.0	6.1
Czech Republic	4.0	-0.9	4.9	-0.4	0.1	1.4	0.6	2.3
Romania	2.0	-2.5	4.5	-1.6	0.2	-0.7	0.2	3.9
Malta	1.6	-1.4	3.0	-0.7	0.3	2.0	1.1	-1.1
Cyprus	2.5	-0.6	3.2	-0.4	0.2	2.1	1.1	-0.5
Lithuania	4.5	-1.1	5.5	-0.6	0.1	1.3	0.5	3.2
Slovenia	4.4	0.0	4.4	0.0	0.3	1.0	0.6	2.6
Estonia	4.3	1.8	2.4	1.1	0.4	0.7	0.0	2.0
Latvia	3.0	0.5	2.6	0.3	0.2	1.3	0.9	0.4
Hungary	3.8	1.1	2.7	0.7	0.1	0.9	0.0	2.2
United States	3.3	**1.1**	2.3	**0.7**	0.3	**0.8**	**1.0**	0.6

Note: Countries are ranked on the basis of their GDP growth in 2003-2007 (see Table 1b)

Source: The Conference Board, Total Economy Database, January 2014

Table 1b: Growth Contributions by Supply-Side Sources of Growth, log growth, 2003-2007

Average growth of 2003-2007		From		Contributions to GDP Growth From				
	Growth rate of GDP	Hours Worked	Labour Productivity	Hours Worked	Labour composition	Non-ICT capital	ICT capital	Total Factor Productivity growth
	1	2	3	4	5	6	7	8
EU-27	2.7	0.9	1.8	0.6	0.3	0.7	0.4	0.7
Euro Area	2.2	0.9	1.3	0.6	0.2	0.7	0.3	0.4
EU-15	2.3	0.8	1.5	0.5	0.3	0.7	0.3	0.5
Sweden	4.8	3.3	1.4	1.8	0.4	2.1	0.9	-0.4
Germany	4.4	2.4	2.0	1.3	0.2	2.5	0.0	0.4
Luxembourg	4.2	1.3	3.0	0.7	0.8	1.7	0.7	0.4
Austria	3.7	0.9	2.8	0.6	0.2	0.2	0.9	1.7
Netherlands	3.4	2.6	0.8	1.6	0.5	1.5	0.4	-0.7
Belgium	3.4	0.8	2.6	0.5	0.2	0.7	0.4	1.5
Finland	3.3	0.8	2.5	0.5	0.4	0.7	0.5	1.1
France	2.6	0.6	2.0	0.4	0.1	0.5	0.2	1.4
Spain	2.4	0.4	2.0	0.2	0.4	0.3	0.3	1.2
United Kingdom	2.2	1.0	1.3	0.6	0.2	0.6	0.6	0.3
Ireland	2.0	0.4	1.6	0.3	0.0	0.4	0.7	0.7
Portugal	2.0	0.8	1.2	0.5	0.2	0.8	0.2	0.4
Denmark	1.7	0.0	1.6	0.0	0.0	0.2	0.3	1.2
Italy	1.3	1.0	0.3	0.6	0.2	0.7	0.1	-0.4
Greece	1.0	-0.1	1.1	-0.1	1.0	0.5	0.7	-1.2
EU-12	5.4	1.2	4.2	0.6	0.3	1.4	0.9	2.2
Poland	9.1	2.0	7.0	1.1	0.1	6.1	0.0	1.8
Slovak Republic	8.3	2.6	5.6	1.4	0.2	3.3	0.0	3.4
Bulgaria	7.8	2.0	5.8	1.1	0.1	3.4	0.0	3.1
Czech Republic	6.8	1.7	5.1	0.7	0.2	1.1	1.3	3.6
Romania	6.2	-0.3	6.5	-0.2	0.3	0.3	0.9	5.0
Malta	6.1	2.9	3.2	1.5	0.4	4.5	1.8	-2.0
Cyprus	5.4	0.5	4.9	0.3	0.3	1.9	0.2	2.8
Lithuania	5.0	1.9	3.1	0.9	0.3	0.9	0.9	2.1
Slovenia	4.7	0.1	4.6	0.1	1.1	1.4	0.5	1.7
Estonia	3.8	2.5	1.3	1.6	0.4	1.0	0.0	0.8
Latvia	3.3	-0.3	3.5	-0.2	0.8	0.7	1.7	0.2
Hungary	2.1	1.0	1.1	0.6	0.2	0.7	0.0	0.5
United States	2.8	1.2	1.7	0.7	0.2	0.6	0.5	0.8

Note: Countries are ranked on the basis of their GDP growth

Source: The Conference Board, Total Economy Database, January 2014

Table 1c: Growth Contributions by Supply-Side Soruces of Growth, log growth, 2008-2013

Average growth of 2008-2013		From		Contributions to GDP Growth From				
	Growth rate of GDP	Hours Worked	Labour Productivity	Hours Worked	Labour compositi on	Non-ICT capital	ICT capital	Total Factor Productivity growth
	1	2	3	4	5	6	7	8
EU-27	-0.1	-0.5	0.4	-0.3	0.1	0.5	0.3	-0.7
Euro Area	-0.3	-0.6	0.4	-0.4	0.2	0.3	0.3	-0.7
EU-15	-0.3	-0.5	0.2	-0.3	0.1	0.4	0.3	-0.8
Sweden	1.0	0.4	0.6	0.3	0.1	0.5	0.6	-0.6
Germany	0.7	0.4	0.3	0.2	0.1	0.2	0.4	-0.2
Luxembourg	0.6	-0.1	0.7	-0.1	0.1	0.3	0.3	0.0
Austria	0.3	0.5	-0.1	0.3	0.2	0.4	0.5	-1.0
Netherlands	0.1	-0.1	0.2	-0.1	0.2	0.6	0.1	-0.7
Belgium	-0.1	1.8	-2.0	0.9	0.2	2.2	0.0	-3.4
Finland	-0.2	0.1	-0.3	0.1	0.1	0.3	0.2	-0.8
France	-0.3	0.2	-0.5	0.1	0.1	0.6	0.2	-1.4
Spain	-0.5	-0.2	-0.3	-0.2	0.2	0.2	1.0	-1.7
United Kingdom	-0.6	-1.0	0.3	-0.7	0.1	0.0	0.7	-0.7
Ireland	-1.1	-2.9	1.9	-1.7	0.3	0.7	0.3	-0.6
Portugal	-1.1	-3.1	2.0	-1.9	0.2	0.9	0.6	-0.9
Denmark	-1.3	-1.1	-0.2	-0.7	0.1	0.0	0.1	-0.8
Italy	-1.3	-2.3	1.0	-1.5	0.6	0.1	0.7	-1.2
Greece	-4.5	-3.4	-1.1	-1.9	0.3	0.3	0.8	-4.0
EU-12	1.3	-0.7	1.9	-0.4	0.2	1.3	0.7	-0.5
Poland	3.0	0.0	3.0	0.0	0.1	1.9	0.8	0.2
Slovak Republic	1.7	0.0	1.7	0.0	0.1	0.6	1.5	-0.4
Bulgaria	1.4	0.8	0.7	0.5	0.2	-0.2	0.0	1.0
Czech Republic	0.7	-1.1	1.7	-0.6	0.2	0.7	0.0	0.3
Romania	0.6	-1.5	2.1	-0.9	0.3	2.6	1.3	-2.7
Malta	0.2	-3.0	3.2	-1.7	0.2	1.3	0.0	0.4
Cyprus	0.2	-0.3	0.5	-0.2	0.1	1.3	0.3	-1.3
Lithuania	-0.4	-2.1	1.7	-1.4	0.2	1.0	0.0	-0.2
Slovenia	-0.8	-1.1	0.3	-0.7	0.2	0.1	1.5	-2.0
Estonia	-1.4	-0.6	-0.8	-0.4	0.3	0.9	0.0	-2.2
Latvia	-1.4	-2.2	0.9	-1.7	0.3	0.3	0.7	-1.0
Hungary	-1.6	-5.2	3.6	-3.0	0.1	0.9	0.0	0.4
United States	1.0	-0.3	1.2	-0.2	0.1	0.3	0.4	0.3

Note: Countries are ranked on the basis of their GDP growth in 2003-2007 (see Table 1b)

Source: The Conference Board, Total Economy Database, January 2014

Table 2a: Growth Contributions by Major Sector of Production, 1996-2002, in log growth						
1996-2002	GDP	Hours	Labor Compo-sition	Non-ICT Capital	ICT Capital	Total Factor Productivity Growth
Austria						
Goods	2.7	-0.9	0.5	-0.1	0.4	2.9
Market Services	3.7	1.1	-0.2	0.4	0.9	1.5
Non-Market Services	1.2	0.9	0.3	0.7	0.2	-0.9
Finland						
Goods	6.0	-0.2	0.6	0.2	0.3	5.2
Market Services	4.1	1.9	-0.3	-0.2	0.3	2.4
Non-Market Services	1.9	0.9	0.2	0.9	0.1	-0.2
France						
Goods	2.1	-1.4	0.7	0.3	0.5	2.0
Market Services	3.3	1.0	0.4	0.6	0.8	0.4
Non-Market Services	1.2	0.1	0.3	0.5	0.3	0.1
Germany						
Goods	1.2	-1.5	0.2	0.1	0.2	2.2
Market Services	1.8	-0.1	-0.5	0.5	0.7	1.1
Non-Market Services	2.2	0.5	0.0	0.8	0.2	0.7
Italy						
Goods	0.6	0.0	0.0	0.5	0.3	-0.1
Market Services	2.6	1.3	0.0	0.8	0.6	-0.1
Non-Market Services	1.1	0.6	0.0	0.7	0.3	-0.5
Netherlands						
Goods	2.0	-0.1	0.3	0.2	0.4	1.2
Market Services	4.3	1.6	0.3	0.7	0.9	0.8
Non-Market Services	1.9	1.2	0.1	0.4	0.5	-0.3
Spain						
Goods	2.7	0.9	0.4	1.0	0.4	0.0
Market Services	4.8	3.3	0.0	1.5	0.7	-0.8
Non-Market Services	2.9	1.8	0.2	1.3	0.7	-1.1
United Kingdom						
Goods	1.3	-1.8	1.1	0.0	0.5	1.5
Market Services	5.2	1.0	0.2	0.8	1.8	1.5
Non-Market Services	2.6	1.0	0.4	0.6	0.4	0.2
Aggregate 8 EU Countries						
Goods	1.6	-0.9	0.4	0.3	0.3	1.5
Market Services	3.2	1.0	0.0	0.7	0.9	0.6
Non-Market Services	1.8	0.6	0.1	0.7	0.3	0.1
Note: Non-market services includes Community, Social and Personal Services and Real Estate						
Source: rolling updates" of EUKLEMS industry-level productivity accounts (www.euklems.net); with updates by The Conference Board to include 2010 and 2011.						

Table 2b: Growth Contributions by Major Sector of Production, 2003-2007, in log growth						
2003-2007	GDP	Hours	Labor Compo-sition	Non-ICT Capital	ICT Capital	Total Factor Productivity Growth
Austria						
Goods	4.5	-0.4	0.6	-0.2	0.1	4.3
Market Services	2.6	0.6	0.2	0.5	0.5	0.8
Non-Market Services	1.8	0.6	0.0	0.7	0.2	0.4
Finland						
Goods	6.1	-0.6	0.3	-0.1	0.4	6.0
Market Services	4.2	1.3	0.1	0.0	0.4	2.4
Non-Market Services	1.0	0.6	0.2	1.2	0.1	-1.1
France						
Goods	1.4	-1.4	0.7	0.0	0.2	2.0
Market Services	2.5	1.0	0.3	0.6	0.4	0.3
Non-Market Services	1.5	0.8	0.1	0.8	0.2	-0.3
Germany						
Goods	4.5	-0.9	0.1	0.0	0.1	5.1
Market Services	1.2	0.2	0.0	0.4	0.3	0.2
Non-Market Services	1.1	0.2	0.1	0.4	0.1	0.2
Italy						
Goods	1.3	0.1	0.5	0.3	0.1	0.3
Market Services	1.7	1.1	0.1	0.9	0.3	-0.7
Non-Market Services	0.9	0.4	0.2	0.7	0.2	-0.5
Netherlands						
Goods	2.0	-1.2	0.4	-0.2	0.2	2.8
Market Services	3.2	0.5	0.3	0.2	0.5	1.7
Non-Market Services	0.9	0.6	0.2	0.5	0.4	-0.9
Spain						
Goods	0.6	-1.4	0.7	0.6	0.3	0.6
Market Services	4.4	2.5	0.1	1.9	0.6	-0.8
Non-Market Services	3.5	2.3	0.3	1.7	0.6	-1.4
United Kingdom						
Goods	-0.2	-2.3	0.3	-0.4	0.0	2.1
Market Services	4.0	1.1	0.1	0.8	0.6	1.3
Non-Market Services	2.3	1.4	0.1	0.8	0.4	-0.3
Aggregate 8 EU Countries						
Goods	2.4	-1.0	0.4	0.1	0.1	2.8
Market Services	2.6	1.0	0.1	0.8	0.4	0.3
Non-Market Services	1.5	0.8	0.1	0.7	0.3	-0.3
Note: Non-market services includes Community, Social and Personal Services and Real Estate						
Source: rolling updates" of EUKLEMS industry-level productivity accounts (www.euklems.net); with updates by The Conference Board to include 2010 and 2011.						

Table 2c: Growth Contributions by Major Sector of Production, 2008-2011, in log growth						
2008-2011	GDP	Hours	Labor Compo-sition	Non-ICT Capital	ICT Capital	Total Factor Productivity Growth
Austria						
Goods	0.6	-0.2	-1.6	-0.1	0.2	2.3
Market Services	0.1	0.0	0.1	0.2	0.4	-0.6
Non-Market Services	1.3	0.2	0.5	0.6	0.1	-0.2
Finland						
Goods	-5.5	-1.7	0.2	-0.4	0.3	-3.9
Market Services	0.0	0.2	0.2	0.1	0.2	-0.7
Non-Market Services	0.5	0.7	0.1	1.0	0.1	-1.4
France						
Goods	-1.4	-0.9	-0.9	0.2	0.2	0.1
Market Services	-0.3	0.1	0.5	0.5	0.2	-1.5
Non-Market Services	0.9	-0.1	0.4	0.7	0.1	-0.1
Germany						
Goods	-0.7	-0.3	-0.8	0.0	0.1	0.3
Market Services	0.8	0.6	-0.6	0.2	0.2	0.3
Non-Market Services	1.1	0.3	-0.1	0.4	0.0	0.4
Italy						
Goods	-3.1	-2.9	-0.1	-0.2	0.0	0.0
Market Services	-1.3	-0.4	0.2	0.2	0.2	-1.4
Non-Market Services	0.2	0.1	0.2	0.0	0.1	-0.3
Netherlands						
Goods	-0.2	-0.7	0.0	-0.1	0.2	0.4
Market Services	-0.3	-0.3	0.7	0.1	0.3	-1.1
Non-Market Services	2.0	1.3	0.3	0.5	0.3	-0.3
Spain						
Goods	-2.4	-2.6	-0.8	-0.1	0.2	0.9
Market Services	-1.4	-2.2	2.0	0.9	0.2	-2.3
Non-Market Services	2.0	1.2	0.8	1.2	0.2	-1.4
United Kingdom						
Goods	-3.8	-1.6	-1.7	-0.3	0.1	-0.3
Market Services	-1.2	-0.5	0.3	0.3	0.4	-1.7
Non-Market Services	0.9	0.4	0.5	1.1	0.2	-1.2
Aggregate 8 EU Countries						
Goods	-1.8	-1.3	-0.7	-0.1	0.1	0.2
Market Services	-0.5	-0.3	0.4	0.4	0.3	-1.2
Non-Market Services	1.0	0.3	0.3	0.6	0.1	-0.3
Note: Non-market services includes Community, Social and Personal Services and Real Estate						
Source: rolling updates" of EUKLEMS industry-level productivity accounts (www.euklems.net); with updates by The Conference Board to include 2010 and 2011.						

Table 3: Contributions from digitalisation to average annual GDP growth for eight major EU economies (2001-2011)

	2001-2007	2008-2011
Technology effect through the ICT-producing sector		
ICT hardware TFP	0.12%	0.05%
Software MFP	0.04%	0.05%
Telecom MFP	0.12%	0.06%
Investment effect from ICT-using industries through capital deepening		
IT investment	0.33%	0.12%
CT and spectrum investment	0.11%	0.09%
Network effects on productivity from ICT use in non-ICT sectors		
TFP from ICT returns to scale in non-ICT sector	0.16%	-0.31%
TFP from ICT adaptions in non-ICT sector	0.09%	0.07%
Total Effects from ICT production, investment and use	0.97%	0.14%

Note: EU-8 refers to the weighted average of contributions for eight EU economies: Austria, Finland, France, Germany, Italy, Netherlands, Spain
and the United Kingdom
Source: Corrado and Jaeger (2014), van Ark (2014), The Conference Board

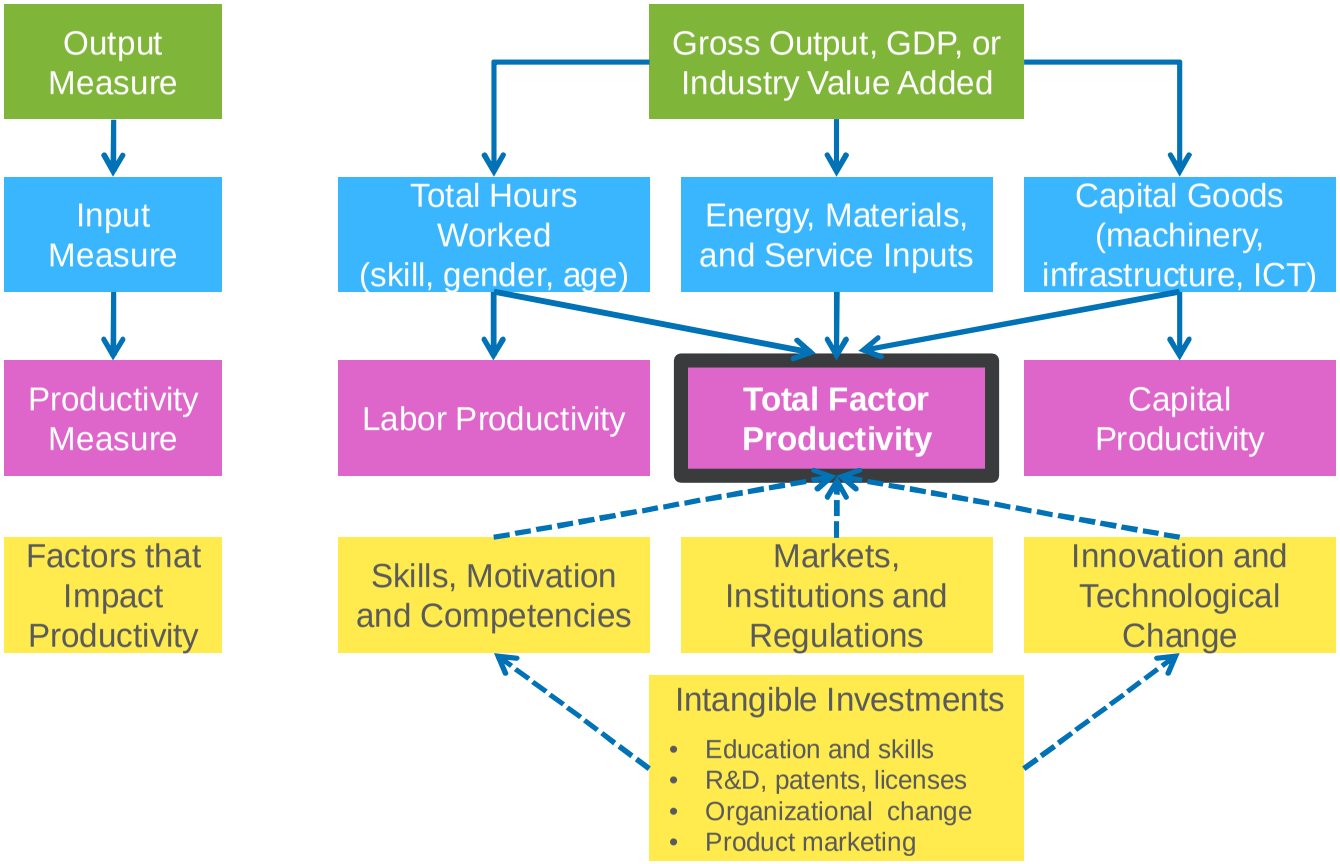
Table 4:Investment intensity of intangible assets as a percentage of GDP for 14 EU economies (1995-2010)

	1995-2002	2003-2007	2008-2010
Computerized Information	0.9%	1.0%	1.1%
Scientific R&D	1.1%	1.1%	1.1%
Other Innovative Property	1.0%	1.1%	1.2%
Market Research & Advertizing	0.9%	0.9%	0.8%
Training	0.9%	0.8%	0.8%
Organisational Capital	1.4%	1.6%	1.8%
Total Itangible Capital	6.2%	6.5%	6.8%

Note: EU-14 refers to the EU-15 before 2004, excluding Sweden and Denmark, but including Slovenia

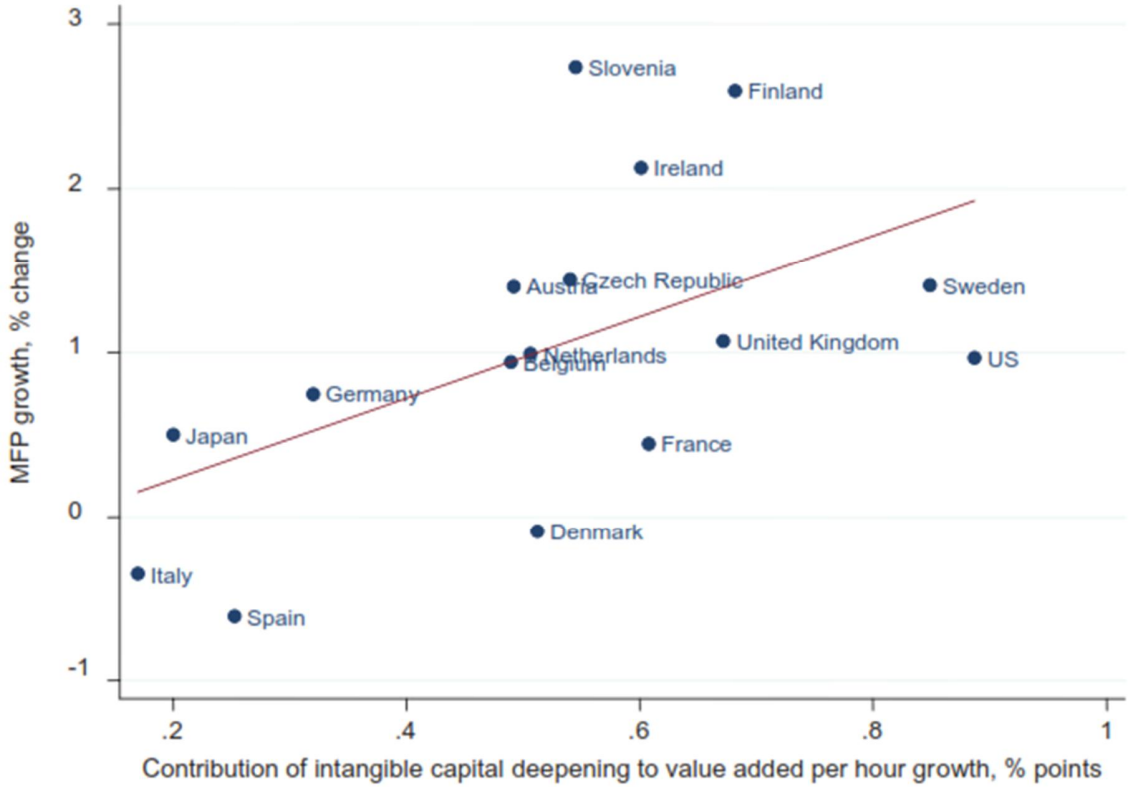
Source: Corrado, Haskel, Jonas-Lasinio and Iommi (2013). The data is also available at www.intan-invest.net.

Chart 1: Extended Growth Accounting Framework and Overview of Growth Contribution



Source: Bart van Ark, The Conference Board®

Chart 2: Relationship between Intangible capital deepening and total factor productivity growth in EU economies (1995-2007)



Source: Corrado et al. (2013b), Figure 11.

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