European Commission

ISSN 2443-8022 (online)

From Mind the Gap to Closing the Gap: Avenues to Reverse Stagnation in Europe through Investment and Productivity Growth

Bart van Ark

FELLOWSHIP INITIATIVE 2014-2015
"Growth, integration and structural convergence revisited"

DISCUSSION PAPER 006 | SEPTEMBER 2015

EUROPEAN ECONOMY

Economic and Financial Affairs

European Economy Discussion Papers are written by the staff of the European Commission's Directorate-General for Economic and Financial Affairs, or by experts working in association with them, to inform discussion on economic policy and to stimulate debate.

The views expressed in this document are solely those of the author(s) and do not necessarily represent the official views of the European Commission.

Authorised for publication by Anne Bucher, Director for Growth, Competitiveness and Structural Reforms.

This paper exists in English only and can be downloaded from http://ec.europa.eu/economy_finance/publications/.

Luxembourg: Publications Office of the European Union, 2015

KC-BD-15-006-EN-N (online)
ISBN 978-92-79-48668-5 (online)
doi:10.2765/755394 (online)

KC-BD-15-006-EN-C (print)
ISBN 978-92-79-48667-8 (print)
doi:10.2765/011445 (print)

European Commission
Directorate-General for Economic and Financial Affairs

From Mind the Gap to Closing the Gap

Avenues to Reverse Stagnation in Europe through Investment and Productivity Growth

Bart van Ark

Abstract

This paper looks at the growth stagnation in Europe since the beginning of the crisis, and places it in the light of the longer-term growth slowdown since the 1990s, as well as the projections forward for the remainder of the decade. Using a growth accounting approach, we compare the sources of the growth gap before and since the crisis. We observe a particularly rapid decline in the contributions of employment and total factor productivity to output growth. The projections to 2020 show that there is a continued large negative growth contribution from total factor productivity, which appears unsustainable. Looking at the growth gap relative to the United States, we find that while ICT capital intensity in Europe has largely converged on the US, the productivity effects were severely impacted by the crisis, especially because of a drop in the returns-to-scale from ICT use in non-ICT producing sectors. In the final part of the paper we focus on one key area to narrow (or even close) the TFP growth gap, by focusing on a shift in investment towards intangible (or knowledge) assets, such as ICT, innovative property and economic competencies. We find that at present the intensity of intangible investment in Europe is still much lower than in the United States. In the final section of the paper we draw conclusions with regard to the policy setting to revive long-term productivity growth through supporting the shift in its asset composition towards knowledge assets, notably the need to complete the single market in services, especially in the digital economy.

JEL Classification: O47, E22.

Keywords: growth gaps, crisis, euro area, investment gap.

Acknowledgments: This paper has been written as part of my assignment as a fellow in the DG ECFIN Fellowship Initiative 2014-2015. I have benefited from comments at the meetings on 23 November 2014 and June 2015. I also received helpful comments and suggestions from Kieran McMorrow and Werner Röger (DG ECFIN). I am grateful to Mary O'Mahony for letting me use some of the work from our joint paper, titled "Productivity Growth in Europe Before and Since the 2008/09 Economic and Financial Crisis", in Jorgenson, Fukao and Timmer, eds., *Growth and Stagnation in the World Economy*, Cambridge University Press, 2016. I am also grateful to Abdul Erumban and Klaas de Vries (The Conference Board) for statistical support. The arguments in this paper are solely mine, and cannot be ascribed to DG ECFIN or The Conference Board.

The closing date for this document was June 2015.

Contact: Bart van Ark, The Conference Board and University of Groningen (h.h.van.ark@rug.nl).

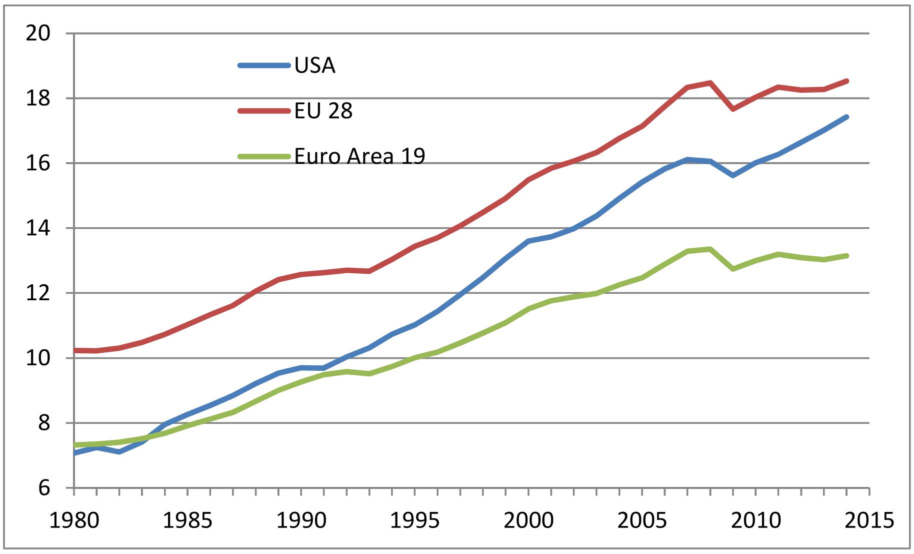
CONTENTS

1. INTRODUCTION

The economic and financial crisis which started in 2008/09 has thrown the European economy into a "double-dip" recession and overall stagnant growth for a lengthy period of time. It created two significant gaps in Europe's growth performance, one relative to its own pre-recession growth performance and another relative to growth performance of the US economy, despite the latter's own challenges to revive since the Great Recession.

The growth shortfall of Europe is very visible at the aggregate level of GDP. In 1980 the level of GDP of what constitutes the EU-28 today, was still 45 percent above that of the United States (**Chart 1**). The gap gradually narrowed to about 10 percent just before the 2008-09 crisis. By 2014, GDP in Europe was only 6 percent above the US level. Since the mid-1990s GDP performance for the Euro Area has weakened even more relative to the US. In 1995 the level of GDP of what is the Euro Area-19 today was about 10 percent lower than the US level, but in 2014 the gap was as big as 25 percent.

Chart 1 - Level of GDP, in trillion 2014 US$ (PPP-converted), 1980-2014



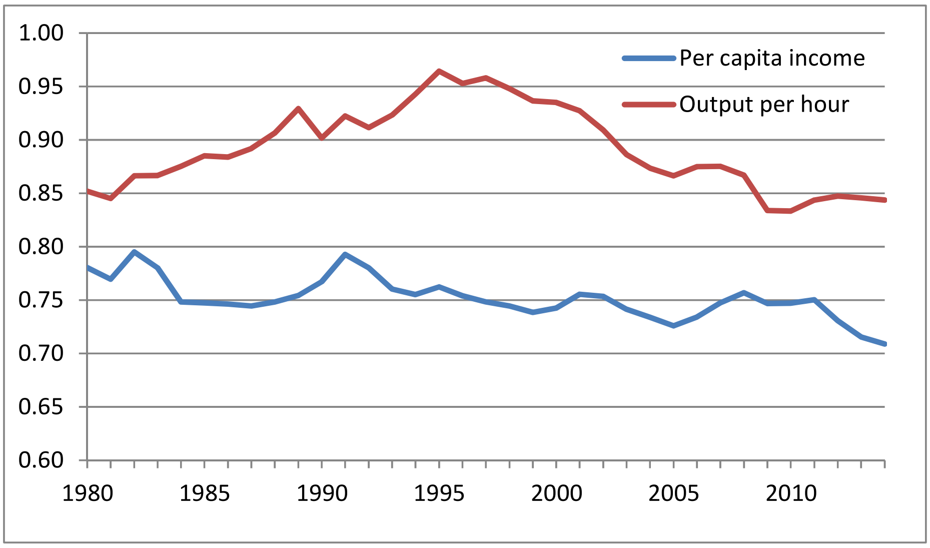
Note: GDP is converted at 2011 PPPs from the International Comparisons Project (World Bank), with GDP rebased to 2014.

Source: The Conference Board Total Economy Database, May 2015

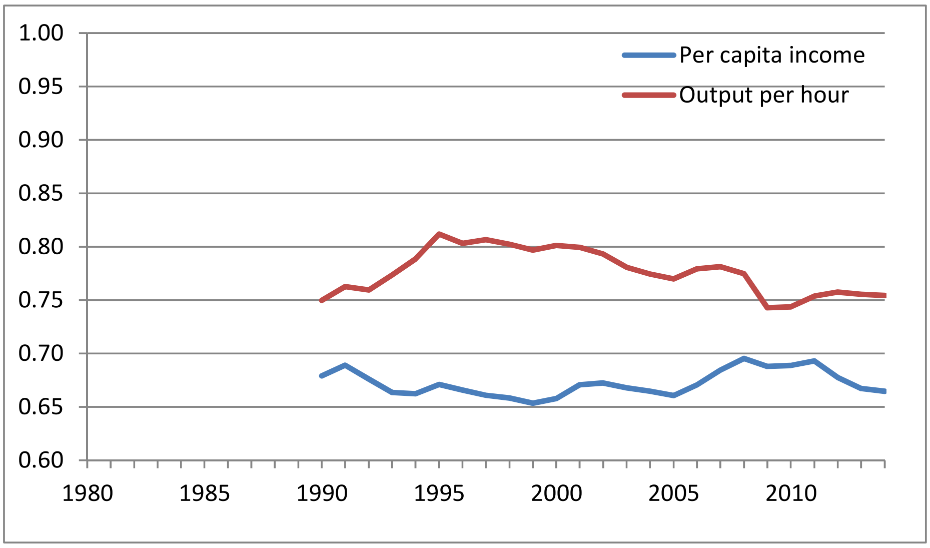
The weaker output performance in Europe is also reflected in a larger per capita income gap relative to the United States. In the Euro Area-19, per capita income hovered between 75 and 80 percent of the US level between 1980 and 1995, but after 1995 per capita income in the Euro Area dropped below 75 percent of the U.S. level, briefly recovered during cyclical upswing around the mid 2000's, but dropped further after the crisis, and especially after 2011, to only 71 percent in 2014 (**Chart 2a**). Per capita income for the EU-28 strengthened somewhat more than in the Euro Area-19 during the mid-2000s, but also dropped off to 67 percent of the US level by 2014 (**Chart 2b**).

Chart 2 - Level of per capita income and labour productivity relative to the United States (PPP-converted), %, 1980-2014

a. Euro Area (USA=1.00)



b. European Union (USA=1.00)



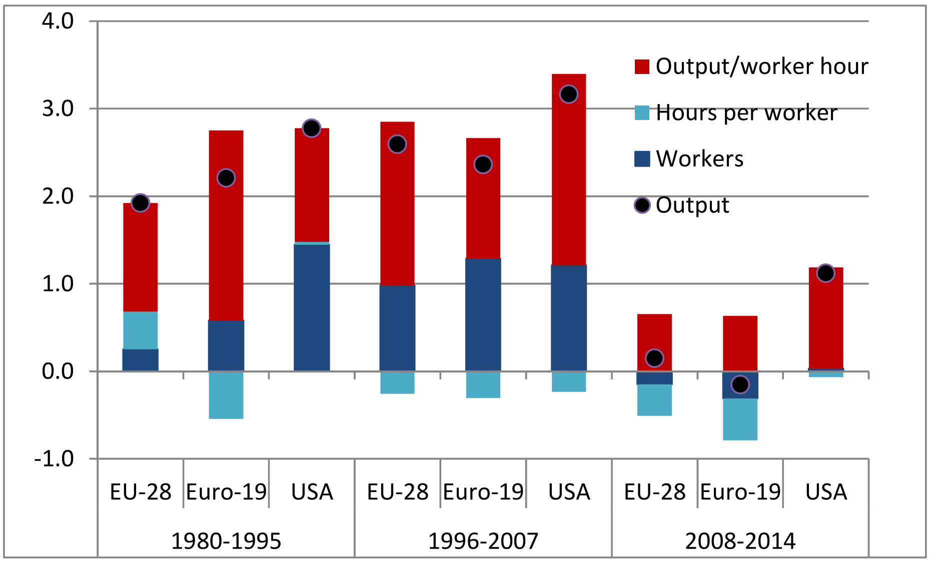
Note: GDP is converted at 2011 PPPs from the International Comparisons Project (World Bank), with GDP rebased to 2014.

Source: The Conference Board Total Economy Database, May 2015

Compared to per capita income, productivity showed a very different pattern relative to the United States. Between 1980 and 1995, the Euro Area showed a rapid closing of the gap in output per hour from 85 percent of the U.S. level to more than 95 percent. During this period, much of Europe's catch-up performance in labour productivity was driven by increased capital intensity and weak employment growth. In new European member states, large restructuring added to the rapid productivity gain. Between 1995 and the start of the 2008-09 crisis, the main culprit for the widening growth gap was weaker productivity performance, especially in the Euro Area (**Chart 3**).

Since the onset of the crisis, the American and most European economies experienced a drastic decline in both employment and productivity growth, creating a growth gap relative to their own pre-recession performance. The initial collapse in employment, the rise in unemployment and the slowdown in productivity was in part related to cyclical factors. However, beyond some short-lived pro-cyclical improvements in 2010, there have been virtually no signs of a significant recovery in productivity growth. Productivity growth in fact weakened strongly in both economies, and as a result the productivity gap in terms of output per hour between Europe and the United States has remained largely unchanged since 2009. However, on employment the European economies seemed much harder hit than the U.S. economy, which some notable exceptions including non-Euro Area economies such as Poland and the United Kingdom.

Chart 3 - Growth Contributions of Employment, Hours per Worker, and Output per Hour to GDP, in log growth



Source: The Conference Board Total Economy Database, May 2015

In this report, we intend to go deeper towards understanding the sources of the growth gap, especially the weak productivity growth performance of most of Europe's economies. Our main argument is that, beyond the collapse in employment growth, the incidence of negative total factor productivity growth is a more important factor for the growth slowdown than most estimates suggest. The main reasons for the collapse in TFP growth are the lack of demand since the crisis, and the failure to invest in what are the most important assets for a productivity recovery, which are the intangible (or knowledge) assets in the economy. The latter include information and communication technology assets, innovative property, and economic competencies, including workforce training, organizational innovations, branding and marketing. In the light of slowing labour supply across European economies, the key is to complement physical (tangible) assets in the economy with intangible assets which drive technological change and innovation.

The remainder of the paper is organized as follows. In Section 2 we provide an update from 2011 to 2014 of the growth accounts decomposition which we originally provided in our earlier paper in 2013 (van Ark et al. 2013). In Section 3 we then take a closer look at projections of the sources of growth to 2020, comparing the decomposition of potential output according to ECFIN to 2019, with The Conference Board's trend growth projections out to 2020. In Section 4, we take a closer look at the decomposition of tangible investment between ICT and non-ICT assets, and provide those in a comparative framework with the US. Section 5 zooms in on the latest estimates for intangible investment which, for European countries, are only available until 2010 but showing a substantial shortfall relative to the United States. Finally, in Section 6 we identify some key areas for policy focus to revive productivity growth through a growth agenda driven by intangible investment and innovation, and market reforms that can help to reap the scale effects from those investments across Europe.

2. GROWTH GAPS BEFORE AND SINCE THE CRISIS

As elsewhere in the advanced world, the global economic and financial crisis significantly affected the economic performance of European economies. Especially the Euro Area suffered from two recessions within three years (2008/09, 2011/12). Outside the Euro Area, the UK also experienced a very deep recession, and several Central and Eastern European economies not in the Euro Area, especially the Baltic States, suffered from the slowdown in external markets and the exposure of their own financial sectors to the crisis.

To understand the weak recovery since the emergence of the crisis, it is important to distinguish between cyclical recession and recovery effects, and the structural impact of the crisis which affect all growth sources (labour, capital and total factor productivity). The analysis in this Section therefore focuses on the pre- and post-crisis trends in economic growth and the sources of growth (hours worked, labour composition, ICT and non-ICT capital, and total factor productivity) for 1999-2007 and 2008-2014 from *The Conference Board Total Economy Database* (May 2015). Hence the first period covers the growth performance between roughly the pre-peaks in the business cycle, whereas the second period begins with the year in which the crisis started (by the end of 2008) until the year (2014) for which the latest data are available at the time of writing.

Output, employment and labour productivity performance

When looking at the impact of the global economic and financial crisis on Europe's growth, the aggregate GDP, employment and labour productivity (GDP per hour worked) metrics capture the first order effects of the response to the crisis (see the first three columns of **Table 1)**. GDP growth in the EU-28 was 2.6 percent between 1999 and 2007, only 0.2 percentage point below the U.S. growth rate over the same period.[1] In the Euro Area, growth was 0.5 percentage points slower than in the U.S. during the pre-crisis period.[2] Strikingly, employment performance, measured as total hours worked, in Europe was relatively strong, with the EU-28 (0.8 percent) and the Euro Area (0.9 percent), on the one hand, and the United States on the other (0.6 percent). Overall productivity growth in Europe was between 0.4 percentage points (EU-28) and 0.8 percentage points (Euro Area) lower than in the United States.

Table 1: Output, Hours and Labour Productivity Growth, and Growth Contributions by Major Input, log growth, 1999-2007 and 2008-2014

				Contributions to GDP Growth From				
	Growth rate of GDP	Hours Worked[1]	Labour Productivity (GDP per hour)	Hours Worked (weighted) [2]	Labour composition	Non-ICT capital	ICT capital	Total Factor Productivity growth
1999-2007								
*EU-27**	*2.6*	*0.8*	*1.8*	*0.5*	*0.2*	*0.8*	*0.5*	*0.6*
*Euro Area***	*2.3*	*0.9*	*1.4*	*0.6*	*0.2*	*0.7*	*0.4*	*0.4*
*EU-15****	*2.4*	*0.9*	*1.5*	*0.6*	*0.2*	*0.7*	*0.5*	*0.4*
*EU-12*****	*4.4*	*-0.1*	*4.5*	*-0.1*	*0.3*	*1.2*	*0.8*	*2.2*
United States	2.8	*0.6*	2.2	0.4	0.2	0.7	0.7	0.9
2008-2014								
*EU-27**	*0.2*	*-0.4*	*0.5*	*-0.2*	*0.2*	*0.5*	*0.3*	*-0.5*
*Euro Area***	*-0.2*	*-0.6*	*0.5*	*-0.4*	*0.2*	*0.3*	*0.3*	*-0.6*
*EU-15****	*0.0*	*-0.3*	*0.3*	*-0.2*	*0.1*	*0.4*	*0.3*	*-0.6*
*EU-12*****	*1.5*	*-0.4*	*1.9*	*-0.3*	*0.2*	*1.1*	*0.7*	*-0.2*
United States	*1.1*	*0.0*	*1.2*	*0.0*	*0.1*	*0.3*	*0.4*	*0.3*

[1] refers to actual log growth rate of total hours worked

[2] refers to the contribution of total hours worked, weighted by the share of labor in total compensation, to the log growth rate of GDP

EU-27 excludes Croatia which became member of EU on 1 July 2013*

*Euro Area** refers to pre-2014 membership of 18 members, excluding Latvia which became a member on 1 January 2014*

*EU-15*** refers to pre-2004 membership of EU*

*EU-12*** refers to new membership of EU since 2004, and excludes Croatia which became member of EU on 1 July 2013*

Source: The Conference Board Total Economy Database™, May 2015

http://www.conference-board.org/data/economydatabase/.

See Appendix Tables 1a and 1b for country details.

The emergence of the financial crisis in 2008 and the two recessions in 2008/09 and 2011/12 caused a large drop in GDP growth in Europe. EU-28 growth dropped to 0.2 percent growth, while U.S. GDP growth slowed to 1.1 percent, leaving a much larger growth gap between the two regions. In 11 of the 27 EU member states, GDP growth contracted over the six-year period. Greece showed the largest drop at -4.3 percent per year between

[1] Measures are for the European Union exclude Croatia, which has been an EU member since July 1, 2013.

[2] Measures are for the Euro Area exclude Latvia and Lithuania, which became a member of Euro Area on January 1, 2014.

2008 and 2014. (See **Appendix Tables 1a and 1b)** Also several large economies, such as Italy (-1.3 percent), and Spain (-0.7 percent) showed a contraction in output. While the Euro Area as a whole saw a decline in GDP at -0.2 percent since the onset of the crisis, some countries within the Euro Area fared comparatively well, such as Germany at 0.7 percent GDP growth on average. In the broader European Union, Sweden still grew its economy at 0.8 percent on average, and Poland showed the fastest GDP growth at 3.1 percent per year on average from 2008-2014.

The GDP slowdown was the result of both a drop in employment and a slowdown in labour productivity growth. The growth rate in total hours declined at -0.4 percent per year in the EU-28 between 2008 and 2014, which resulted from a combination of higher unemployment and a decline in the labour force participation rate. Growth in output per hour worked slowed from 1.8 percent in the EU-28 between 1999 and 2007 to a still positive 0.5 percent growth between 2008 and 2014.

Underlying the EU-wide slowdown in productivity growth are stark differences between countries. The biggest declines in labour productivity growth in Euro Area countries were seen in Greece (-0.9 percent) and Finland (-0.3 percent). (See **Appendix Tables 1a and 1b)** These productivity declines were related to the large decline in GDP growth in those economies. In Germany, despite a rise in GDP and per capita income growth at 0.7 percent each, labour productivity increased at only 0.4 percent between 2008 and 2014, suggesting labour hoarding effects as a result of short-time working programs in 2008 and 2009 In contrast, labour productivity growth in Poland increased by 2.8 percent per year between 2008 and 2014, which resulted from an expansionary growth phase adding to both output and employment. Strikingly, Spain also saw an acceleration in labour productivity growth at 1.7 percent, but, in contrast to Poland, it resulted from reducing hours even more than GDP.

A sources-of-growth analysis

Using a standard growth accounting framework, following Jorgenson, Ho and Stiroh (1995), the remaining columns of **Table 1** decompose the growth of aggregate GDP into the contributions of labour, capital and TFP. While Europe and the Euro Area saw a faster increase in the contribution of working hours to growth from 1999 to 2007 than the United States, hours have contributed negatively since the beginning of the crisis whereas they provided a zero contribution in the United States. Cyclical factors played some role in hitting Europe's labour market harder than the United States as domestic demand was more heavily affected, although some countries (notably Germany) muted the issue partially by labour hoarding programs. Indeed growth in total hours still contributed 0.2 percentage points in Germany (together with a moderate increase in labour productivity growth – see Bellmann et al. 2015). In the United Kingdom total hours still contributed as much as 0.5 percentage points to growth although offset by a small decline in labour productivity growth (see Barnett et al, 2014). Further information of individual countries is provided in **Appendix Tables 1a and 1b.**

Capital services, split between ICT and non-ICT capital, have been the main driver of GDP growth in the aggregate EU and the U.S.. Before the crisis, non-ICT capital accounted for about 0.8 percentage points of GDP growth in the EU, but declined to 0.5 percentage points since the crisis. In the Euro Area the contribution of non-ICT capital dropped from 0.7 to 0.3 percentage points, which was comparable to the drop-off in the United States. In contrast to most European economies, the Polish economy showed the biggest deviation from the

European average: it saw the non-ICT capital contribution increase from 0.9 percentage points from 1999-2007 to 1.6 percent from 2008-2014 (Piatkowski, 2013).

The contribution of ICT capital in Europe, which had already slowed in the early 2000s relative to late 1990s, only slowed modestly more during the crisis. During the 1995-2007 period, the U.S. advance in the ICT capital contribution to growth was higher (at 0.7 percentage points) than in Europe (at 0.5 percentage points) and the Euro Area (at 0.4 percentage points). In the U.S., much of the faster investment pace during the "new economy" era of the late 1990s was driven by the scale effects from larger U.S. markets, especially in market services such as trade and transportation, which couldn't be easily replicated in Europe (Inklaar et al. 2008). However, since 2008 the ICT capital contribution to growth slowed down considerably in both regions, and even slightly more in the United States (from 0.7 to 0.4 percentage points) than in the EU-28 (from 0.5 to 0.3) or the Euro Area (from 0.4 to 0.3). However, the ICT capital contributions still strengthened in Nordic economies (Denmark, Finland and Sweden), whereas they weakened most strongly in France, Italy, Spain and the UK.
In Sections 4 and 5 we will address the role of investment relative to the economies' productivity performance in more detail. First we address the aggregate TFP performance, which has emerged as the Achilles' heel of Europe's growth performance. Between 1999 and 2007, TFP growth in the EU-28 was 0.6 percent (two thirds of the US growth rate at 0.9 percent) and only 0.4 percent in the Euro Area (less than half of that in the US). Central and Eastern European economies mostly exhibited much faster TFP growth, as they still benefited from "catchup growth" during the 1990s and most of the 2000s.

Since 2008, Euro Area TFP growth has turned negative for all Euro Area economies. Even relatively strong economies like Germany could not maintain TFP growth at positive rates, showing a decline of 0.2 percent (See **Appendix Tables 1a and 1b)**. The continuation of the slowing trend in TFP growth points at a range of possible explanations. Beyond the temporary cyclical impact from the recession related to weak demand, it can be a sign of weakening innovation and technological change as companies hold back on new investment due to longer term concerns about demand and investment (Teulings and Baldwin, 2014). But for the TFP growth rate to turn negative, additional explanations are needed. First, it could signal the greater force of rigidities in labour, product and capital markets during the crisis, causing increased misallocation of resources to low-productive firms. This is especially so in times during which scale-dependent technologies such as communication technology require flexibility across a larger economic space. Limited scale effects in Europe, related to fragmented markets and limited impacts from ICT utilization might have played a larger role than in the United States. Related to the previous explanation, there might be a negative reallocation effect, with more resources going to the less productive sectors in the economy.[3]

Finally, it should be stressed that we cannot entirely exclude a possible measurement issues related to the introduction of new technologies and subsequent innovations. The potential productivity gains from the combination of ubiquitous broadband and mobile, supported by cloud computing and big data analytics, and

[3] For the latest review of current estimates, see The Conference Board Total Economy Database (https://www.conference-board.org/data/economydatabase/). See also The Conference Board (2015).

reflected in the rise of apps economy and the sharing economy, provided huge measurement issues. Inadequate price measures, a failure to measure consumer surplus (even though it is not supposed to be in the conventional GDP measure anyway) and, importantly, the inadequate reflection of the productivity gains from the apps economy in the output statistics, may all contribute to the mismeasurement story. Recently, there has not been a comprehensive assessment of price change bias from new products and services for some time. There is an urgent need for the kind of measurement breakthrough we saw in the 1990s when price measures for PCs got adjusted for quality change, which drastically improved the measurement of productivity in the tech sector of the economy. However, from the perspective of understanding the growth gap in TFP across the Atlantic, it is unlikely that the measurement bias is any bigger in Europe than in the United States.[4]

3. CLOSING THE GROWTH GAP IN THE EURO AREA

To provide estimates of future project growth performance, a variety of projection and forecasting methods are available. The most frequently used methodology is the estimation of potential output growth using a production function approach, akin to the historical growth accounting methodology which was employed in the previous section, which measures the future contribution of inputs (labour and capital) to produce output (goods and services) for consumption and investment.[5] Assuming the full utilization of inputs, this provides a measure of potential output level (growth) which represents the maximum sustainable output level (growth) without increasing inflationary pressures and given the current state of technology. Potential output therefore measures the structural growth path of the economy. The trajectory of potential output can change over time as a result of shifts in the demand-supply relationships in the markets for labour and capital, or the long-term path of technological change, which in turn can be driven by long-term shifts in demand. In order to obtain projections of actual output, the potential output methodology needs to take account of cyclical fluctuations, which determine deviations from the long-term trend. This last step in growth projections is a very difficult one as the cyclical factors are not easy to disentangle from the structural factors described above. For example, to what extent has the slow growth in employment been caused by a rise in cyclical unemployment vis-à-vis an erosion of long-term employment opportunities leading to lower labour force participation?

The European Commission's official growth forecasts are based on the potential output growth method, using the production function methodology.[6] **Chart 4** shows the Commission's potential output growth for the Euro Area, which is decomposed into the contribution of total hours, physical capital and total factor productivity growth, together with the actual output estimates out to 2020. The chart shows that actual output growth as of 2015 will surpass potential output growth as the economy is returning to full capacity – a process to continue at least until the end of the decade. The estimates show an only modest improvement in total potential hours, related to the slowing labour supply in European economies. Also the investment recovery is seen as relatively

---

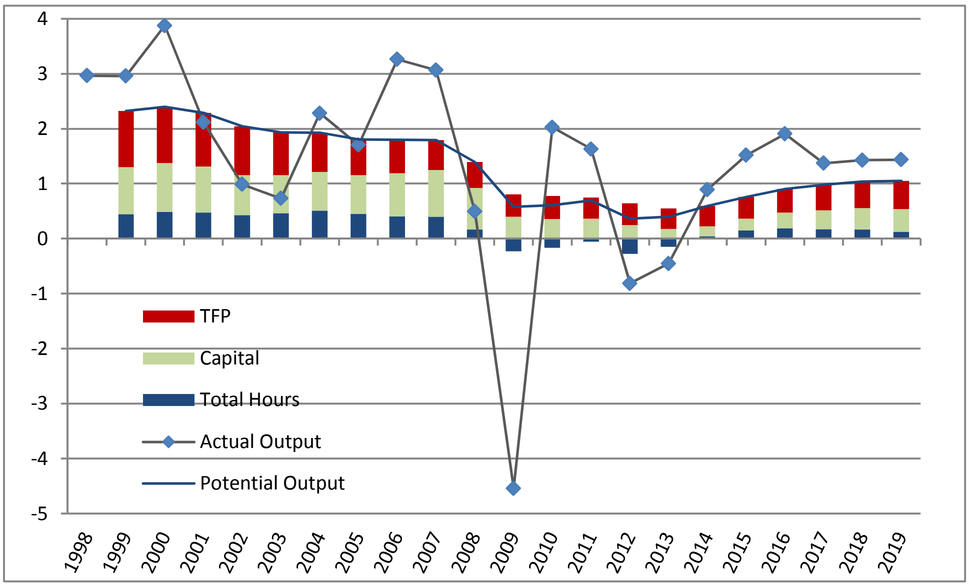
[4] For a recent commentary, see my blog post on http://tcbblogs.org/economy/2015/07/22/blaming-the-productivity-slowdown-on-measurement-issues-takes-our-eyes-off-the-ball/.

[5] While energy, materials and service inputs should, in theory, also be included in the production function approach, they are abstracted from in potential output estimation.

[6] For the latest update of the methodology, see Havik et al. (2014), including a new specification in the Commission's estimates of the NAWRU (non-accelerating wage rate of unemployment) based on a new Keynesian Phillips Curve (NPK) based on a rational expectations case, and an extension of the long-term growth projections from 5 to 10 years.

slow, while potential TFP growth is forecasted to slowly recover from 0.4 (from 2008-2014) to 0.5 percent (from 2015-2019). While this seems a small improvement, this projection implies that the share of TFP in potential GDP growth for the period 2015 to 2020 will rise considerably compared to the pre-crisis period. Between 1999 and 2007, potential TFP on average accounted for 40% of potential GDP growth, whereas the projections for 2015-2020 show the average TFP contribution raised to 50% - despite the fact that the potential TFP growth rate for this period (0.45 percent) is only just over half of the potential TFP growth rate for 1999-2007 (0.8 percent).

Chart 4 – Sources of Potential Output Growth for the Euro Area, in %, 1998-2019

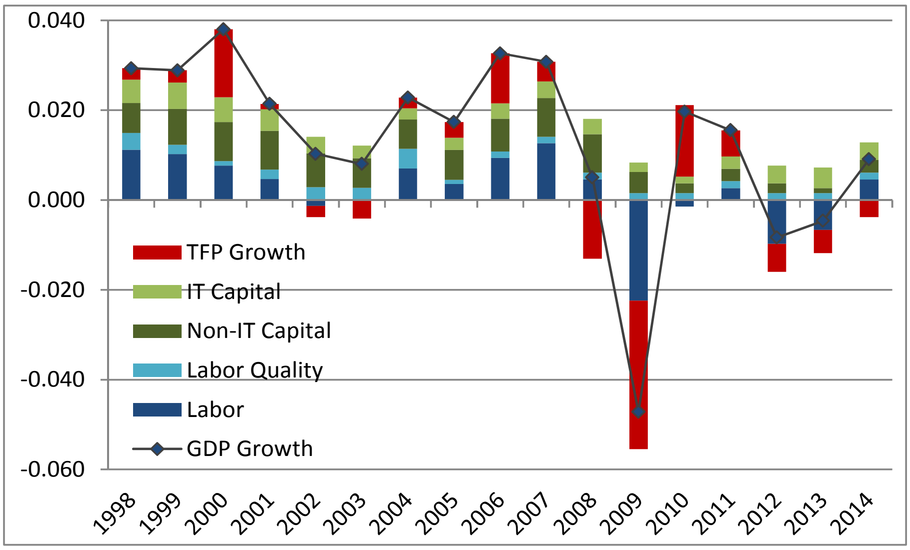


Source: Derived from DG ECFIN, Spring 2015 Forecasts, European Commission (data provided by DG ECFIN upon request).

Estimates from *The Conference Board Total Economy Database* supplement with projections from *The Conference Board Global Economic Outlook*, do not disagree much on the aggregate GDP growth projections, but more on the decomposition of those projection especially the estimates of TFP. For example, actual TFP growth, on the basis of historical data from as shown in the previous section, was in fact much slower than potential TFP growth derived from the Commission's data (**Chart 5**). For example, from 1999-2007 potential TFP growth was 0.8 percent in the Commission's model, whereas actual TFP growth on TCB's measures was only 0.4 percent. From 2008-2014, potential TFP growth slowed to 0.4 percent while actual TFP growth dropped to -0.6 percent. Clearly negative demand factors have impacted total factor productivity growth rates much more than those for capital, but comparable to labour inputs.[7]

[7] For example, the growth contribution from potential labour supply in the Commission estimates slowed from 0.45 percent from 2000-2007 to -0.1 from 2008-2014, whereas TCB's actual growth in hour worked slowed from 0.6 percent to -0.4 percent.

Chart 5 – Sources of Actual GDP Growth for the Euro Area, in %, 1998-2014



Source: [The Conference Board Total Economy Database](), May 2015

Indeed, when looking at an alternative way of projecting output growth, it turns out that the decomposition of growth sources comes out somewhat differently. Instead of projecting potential output growth, *The Conference Board Global Economic Outlook* estimates the growth trend on the basis of the actual sources of growth for previous periods. The latest version of this global model includes projections for 11 major regions (including Europe and the Euro Area) and individual estimates for 33 mature and 22 emerging market economies for 2015, 2015-2019, and 2020-2025. The projections are based on a supply-side growth accounting model that estimates the actual (rather than potential) GDP contributions of the use of factor inputs – labour (quantity and educational composition) services, capital services and total factor productivity growth.

TCB's global outlook model[8] estimates labour input growth rates using information on demographic changes and work force participation rates. An adjustment is also made for changes in the composition of the labour force to measure labour's effective contribution to output growth, mainly based on the projection of population by level of educational attainment. Capital services and total factor productivity growth are econometrically estimated by a system of three equations using a range of explanatory variables. The model constitutes a simultaneous equation system for three endogenous variables (TFP growth, the savings rate, and capital services growth[9]) which is estimated using three-stage least squares. All other variables are either exogenous or predetermined, and include economic variables (such as wage growth, inflation, energy use, R&D expenditure, depreciation, etc.) and institutional and structural variables (such as sector share, human development index, corruption). As the model is globally estimated it makes use of country fixed effects to provide estimates for

[8] For a review see Erumban and de Vries (2014). For data, see https://www.conference-board.org/data/globaloutlook

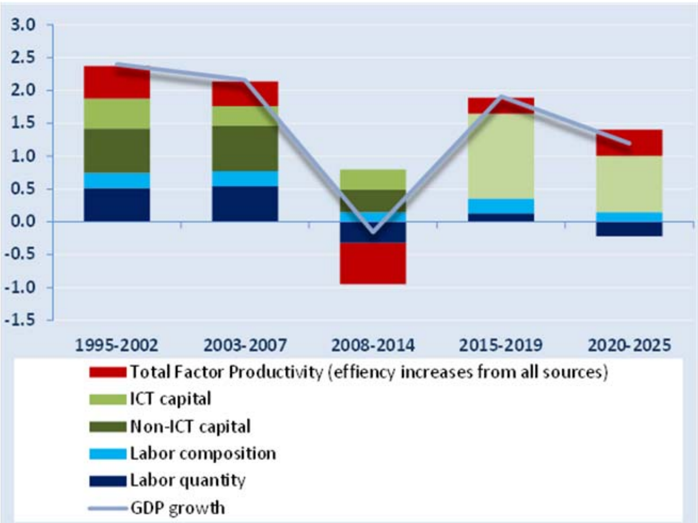
[9] The savings rate is important to add in, because it is closely related to investment in capital that determines the growth of capital services. Moreover, savings, representing the other part of consumption, also related to elements of demand in our otherwise supply side model.

individual countries and regions. The model is also estimates for eight sub-periods (of which six historical periods back to 1972) and two projection periods (2015-2019 and 2020-2025).

The projected GDP growth rates based on the growth accounting framework are to be interpreted as the trend growth rates of an economy, and are assumed to converge on the potential output growth rate in the longer-term. In the short run, however, countries may deviate from their long-run path due to temporary factors primarily, in particular their business cycle dynamics. In the final stage, therefore, the 2015-2019 estimates are adjusted for an estimate of the remaining gap between actual and potential output. For example, for the Euro Area, the adopted output gap estimate was 2.8 percent for 2014, which was assumed to be closed over the next five. This causes an adjustment of the Euro Area projected growth rate from a trend project of 1.3 percent to an actual growth projection of 1.9 percent for 2015-2019.

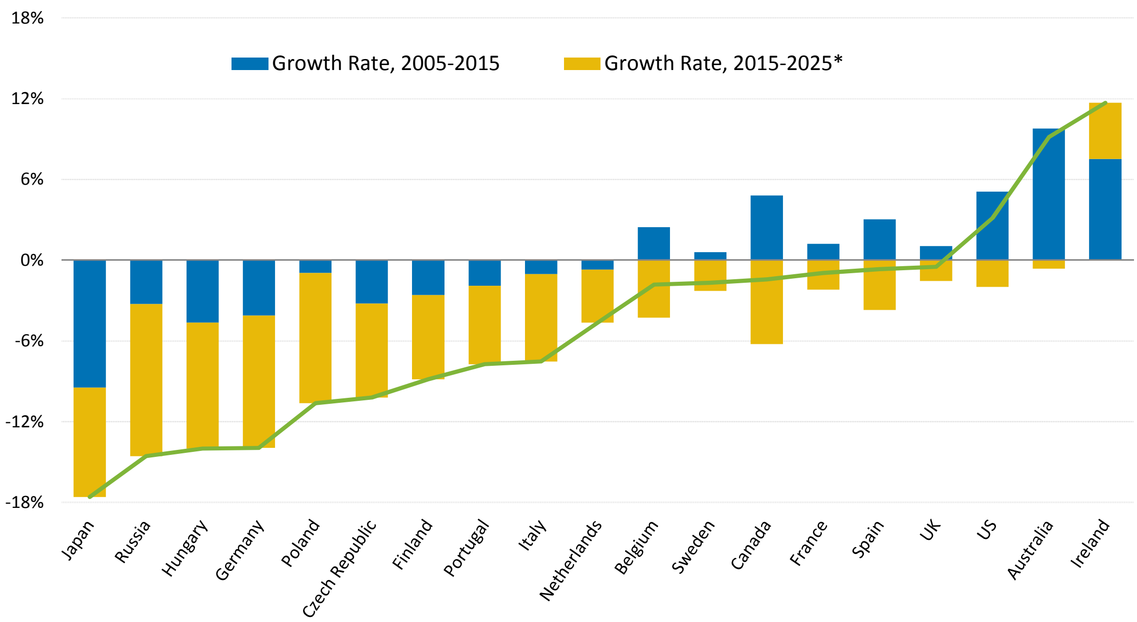
Chart 6 shows that the projected output growth rates, using TCB's trend methodology provide a smaller growth contribution from employment and TFP growth. The weaker employment growth contributions are directly related to the estimates of labour supply, which are based on the working age population (15-64) growth rates, which show an accelerating decline from 2015-2025 compared to 2005-2015 for most European countries (see **Chart 7**). The decline in the unemployment rate, the rise in pension and a potential positive effect from migration may somewhat offset the long-term trend of slowing labor supply. But those changes are largely overshadowed by the large group of retiring workers over the next 15 years. The TCB estimates put the contribution of employment growth at only 6 percent of aggregate growth compared to 15 percent in the Commission estimates from 2015-2019.

Chart 6 – Trend Growth Projections for Euro Area, 1996-2025, in %



Source: The Conference Board Global Economic Outlook, November 2014.

Chart 7: Change in Natural* Working Age Population (25-64 years), in %



* "Natural" refers to growth in population excluding migration
Source: United Nations Population Division

The bigger differences between the TCB and Commission growth projections arise from the estimated contributions of capital and TFP growth. Comparing **Charts 4 and 6** shows that the Commission's contributions of TFP relative to capital growth are much bigger than in the TCB estimates from 2015-2019. Whereas, the capital contribution makes up about one third of the potential output contribution in the Commission model, and TFP close to 50 percent, the corresponding estimates from the TCB model are two thirds for capital and one quarter for TFP (including the labour composition adjustment) relative to actual output.[10]

The differences between the sources of the growth gap in the Commission's potential growth estimates versus TCB's trend projections, raise an important question on whether the projected decomposition of the potential growth sources can actually be realized. While the mix of capital and TFP between the potential sources of growth might be reasonable, the actual growth projections suggest a level of investment that cannot be sustained at the projected TFP growth rates.

As mentioned above, a recovery in demand is likely to strengthen TFP in the TCB model. However, beyond that we need to take a deeper look at the sources of investment growth which determine the capital contribution, and which is the key lever to strengthen TFP growth from the supply-side.

[10] The labour composition adjustment, which is not separately estimated in the Commission model, is therefore included with the TFP estimates in the TCB model.

4. THE INVESTMENT GAP 1: TANGIBLE CAPITAL

Investment and Capital in ICT and non-ICT assets

As a first step in understanding the role of investment we look at the growth contributions from tangible assets, including machinery, equipment and structures, for which investments are included in the national accounts and their contributions are part of GDP.[11] **Table 2** (Panel A) shows that Europe's aggregate investment-output ratios have been slightly higher than in the US, both before and since the crisis. The somewhat higher ratios for the EU-28 versus the Euro Area mainly reflect catch-up investment in Central and East European economies. When splitting up tangible investment into non-ICT and ICT assets (including hardware, software and telecommunication equipment), the investment-output ratios in non-ICT declined less rapidly in Europe than in the US between 1999-2007 and 2008-2014, whereas ICT investment-output ratios kept rising at about the same rate in both regions. Hence, despite the slowdown in investment and output growth since the crisis, the importance of ICT investment relative to output kept increasing significantly in both Europe and the United States.[12]

Table 2: Measures of Investment and Capital Growth and Intensity, Total, Non-ICT and ICT

	USA	EU-28	Euro Area-19		USA	EU-28	Euro Area-19
Panel A	Total Investment-Output Ratio (real)			***Panel C***	Total Capital-Output Ratio (real)		
1999-2007	12.5%	13.0%	12.7%	1999-2007	1.55	1.52	1.55
2008-2014	12.1%	13.4%	12.8%	2008-2014	1.56	1.66	1.68
	Non-ICT Investment-Output Ratio (real)				Non-ICT Capital-Output Ratio (real)		
1999-2007	10.3%	11.3%	11.3%	1999-2007	1.49	1.48	1.51
2008-2014	8.8%	10.6%	10.4%	2008-2014	1.47	1.57	1.61
	ICT Investment-Output Ratio (real)				ICT Capital-Output Ratio (real)		
1999-2007	2.2%	1.7%	1.4%	1999-2007	0.06	0.04	0.04
2008-2014	3.2%	2.8%	2.4%	2008-2014	0.09	0.08	0.07
Panel B	Total Capital Stock, % growth			***Panel D***	Total Capital-Hour Ratio (real)		
1999-2007	2.1%	2.5%	2.3%	1999-2007	88.2	70.9	80.1
2008-2014	1.1%	1.7%	1.3%	2008-2014	101.4	83.6	92.6
	Non-ICT Capital Stock, % growth				Non-ICT Capital-Hour Ratio (real)		
1999-2007	1.8%	2.3%	2.1%	1999-2007	85.0	68.8	78.1
2008-2014	0.8%	1.3%	0.9%	2008-2014	95.5	79.4	88.7
	ICT Capital Stcok, % growth				ICT Capital-Hour Ratio (real)		
1999-2007	9.5%	10.2%	8.8%	1999-2007	3.3	2.1	2.0
2008-2014	6.3%	8.9%	8.6%	2008-2014	5.8	4.2	3.9

Source: The Conference Board Total Economy Database, May 2015

While the ongoing shift in investment from ICT to non-ICT should, in principle, be a positive for productivity growth, it of course depends on how much that investment adds to the existing capital stock. Panel B in **Table 2** shows that the growth in the capital stock slowed down by on average a full percentage point per year in both

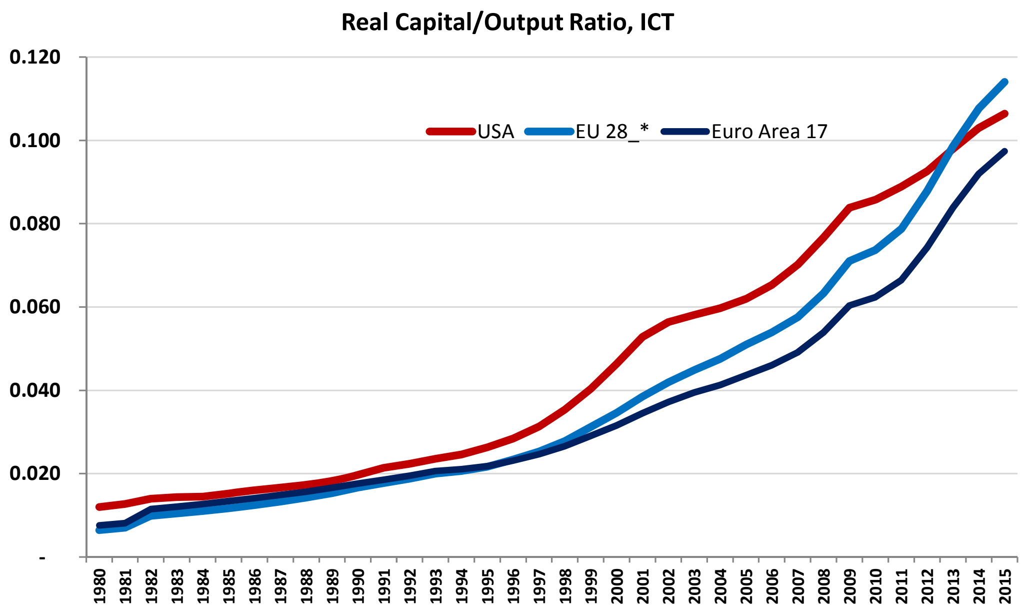
[11] In recent years, the measurement of investment in tangible assets in the System of National Accounts has gradually been expanded to include some elements of intangible capital, including software, entertainment, literary and artistic originals, mineral exploration and – most recently following the introduction of SNA 2008 and ESA 2010 – research and development), but the share of those intangibles is still small compared to the larger group of intangibles or the old tangibles category (see Section 5).

[12] See Appendix Table 2 for a review of different measures of investment and capital intensity by country.

the United States and the Euro Area-19, and 2008-2014, and slightly less in the EU-28, between 1999-2007. However, when looking at ICT separately, the technology capital stock showed a much slower increase in the U.S. than in Europe, and especially in the Euro Area since the crisis. Between 2008 and 2014, the Euro Area-19 capital stock increased at 8.6 percent per year on average versus 6.3 percent in the United States.

Panel C in **Table 2** shows that relative to GDP, the EU-28 and the Euro Area-19 both showed a rise in capital-output ratios between 1999-2007 and 2008-2014, suggesting that the rise in the capital stock more than offset the decline in output. The European economy therefore became more capital intensive relative to the U.S., where aggregate capital-output ratios remained unchanged. However, the ICT capital-output ratio increased in both Europe and the U.S., and Europe showed a significant catch upon the U.S.. Especially in the EU-28 ICT capital-output ratios seemed to have fully caught up with the U.S. level in recent years, and the gap between the Euro Area-19 has also significantly narrowed (**Chart 8**).

Chart 8 - Level of ICT capital stock per unit of output, in 2014 US$ (PPP-converted)



Source: The Conference Board Total Economy Database, May 2015

The evidence on the rise in Europe's ICT capital-output ratios is in accordance with the discussion in Section 2, which showed that before the crisis the contribution from ICT capital to GDP growth was more favorable to the United States (0.7 percentage point in the U.S. versus 0.5 percentage point in the EU-28 and 0.4 percentage in the Euro Area-19 from 1999-2007), whereas it seemed more to Europe's advantage since the crisis (with a slowdown of only 0.1 to 0.2 percentage points, whereas the U.S. contribution slowed by 0.3 percentage point (**Table 1**).

However, what does investment mean for productivity? As the flip side of high capital-output ratios suggests low productivity of capital, it is important to relate to the amount of ICT capital per hour worked in order to determine the level of labour productivity.[13] Panel D in **Table 2** shows that despite the faster rise in capital stock and capital intensity in Europe, the amount of capital per hour worked remained well below the U.S. level, suggesting still lower levels of labour productivity in Europe, as evidenced in the introduction of this report. In sum, while the gap in investment and capital intensity has been somewhat reduced between Europe and the United States, there seems no clear positive impact on a faster growth of productivity.

The already high level of capital per hour worked combined with higher capital intensity (or lower capital productivity) in Europe raises an important policy question on how and where more investment will have larger or smaller growth effects on growth. For example, the introduction of the European Commission's Investment Plan has allocated 315 billion euros to mobilise strategic investments in key areas such as infrastructure, education, research and innovation, as well as risk finance for small businesses. The productivity effects of those different types of investment can be very different. For example, in a recent report the German Institute for Economic Research has argued to focus a closure of the gap in private investment, which is estimated to have fallen significantly behind the "optimal" rate of investment, in accordance with macroeconomic conditions since the emergence of the crisis (DIW, 2014).

To evaluate the productivity impact of different types of investment is a complex undertaking requiring an econometric specification to determine the marginal productivities of an increase in investment by asset type. In the remainder of this section we focus on the role of investment in ICT assets, which have one of the largest return on output growth. To better understand the impact of ICT on productivity, one can distinguish three different types of productivity effects from ICT 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, U.S. productivity growth in the ICT producing sector (including hardware, software and telecommunications) grew at 10.2 percent for labour productivity and 7.3 in terms of TFP growth from 1999-2007. In most European countries productivity growth rates in ICT production were mostly less than half of that (van Ark and O'Mahony, 2015). Even though ICT-producing industries only represent a small part of the economy (about 8% of total GDP in Europe), they accounted for more than 40% (or 0.28 percentage points) of aggregate total factor productivity growth in the market sector in the EU from 2001-2007 (See **Table 3;** Corrado and Jäger, 2014).[14] Even though European countries continued to grow employment In the ICT sector since the emergence of the crisis, total productivity growth dropped significantly to only 0.16% from 2008 to 2011. However, it the same time it remained one of the only sources of TFP growth that remained positive in recent years.

[13] That is: Y/H = (C/H) * (Y/C), meaning that output (Y) per hour (H) is determined by capital (C) per hour (H) times capital productivity (Y/C)

[14] The estimates in Corrado and Jäger (2014) are for 2001-2007 and 2008-2011 and for only eight European countries (Austria, Finland, France, Germany, Italy, the Netherlands, Spain and the United Kingdom).

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 documented above, the investment effects from ICT in Europe slowed significantly since crisis, even though less so than in the United States. **Table 3** shows that the ICT contribution (including investment in spectrum) to growth, was 0.44 percentage point from 2001-2007 and 0.21 percentage point from 2008-2011, slightly lower than the aggregate ICT investment effect of 0.3 percentage point in Table 2 for 2008-2014.

Table 3 - Productivity contribution from digitalization to average annual GDP growth for eight major EU economies, 2001-2011

	2001-2007	2008-2011
Technology effect through the ICT-producing sector		
TFP growth from ICT hardware	*0.12%*	*0.05%*
TFP growth from software	*0.04%*	*0.05%*
TFP growth from telecommunication	*0.12%*	*0.06%*
Subtotal	*0.28%*	*0.16%*
Investment effect from ICT-using industries through capital deepening		
IT investment	*0.33%*	*0.12%*
CT investment, including spectrum	*0.11%*	*0.09%*
Subtotal	*0.44%*	*0.21%*
Netword effects on productivity from ICT use and in non-ICT sectors		
TFP growth from ICT returns to scale in non-ICT sector	*0.16%*	*-0.31%*
TFP growth from ICT adaptions in non-ICT sector	*0.09%*	*0.07%*
Subtotal	*0.25%*	*-0.24%*
Total effects from ICT production, investment and use	*0.97%*	*0.13%*

Note: EU-8 refers to the weighted average of contribution for eight EU member states: Austria, Finland, France, Germany, Italy, Netherlands, Spain and the United Kingdom

Source: Corrado and Jaeger (2014), figure 4; Van Ark (2014), The Conference Board

3. Network effects on productivity from ICT use.

While positive for labour productivity growth, ICT investment does not automatically lead to greater efficiency in the economy, as measured by total factor productivity growth. The TFP effects of using new technology are not easy to identify, quantify and disentangle from other (related) factors impacting on productivity. While significant progress has been made in measuring the contribution of ICT production and investment to productivity, traditional standard growth accounts do not suffice to nail down which part of TFP growth can be linked to spillover effects and externalities from ICT. Network effects from digitalisation, which include higher returns to scale due to more connectivity between businesses and innovative adaptations from ICT across the economy, are key to generating productivity growth.

Network externalities come in two parts:

1. a return-to-scale effect, which directly relates to Metcalfe's law, which states that the value of a network increases with the square of the number of users of the network; and
2. the productivity effects from innovative adaptations from the use of, for example, the Internet and wireless technologies.

The productivity impacts of the two network effects, which are obtained from an econometric analysis for eight European countries (see footnote 14), show these effects to be quite low.[15] For example, between 2001 and 2007, the returns-to-scale (Metcalfe) effect accounted for as little as 0.16 percentage point of total factor productivity growth in the eight European countries. During the 2008-2011 period, the returns-to-scale effect detracted 0.31 percentage point from total factor productivity growth. 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.

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 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-to-scale portion of total factor productivity through ICT use in the non-ICT sector contracted sharply and became negative, bringing the overall contribution of ICT to output growth down from 1% in the 2001-2007 period to 0.1% in the 2008-2011 period.

5. The Investment Gap 2: Intangible Capital

The direct impact of ICT (and other technologies) on productivity and its indirect productivity effect through the adoption of those technologies across the economy should not be considered in isolation from a broader concept of investment beyond the tangible assets defined in Sectoin 4. In recent years a new literature has emerged highlighting that organisational changes and other forms of intangible investment such as workforce training are necessary to gain significant productivity benefits from using ICT (Brynjolfsson, Hitt and Yang, 2002; Black and Lynch, 2001).

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 require a significant adjustment of the statistical measurement framework. Traditionally the expenses on such intangibles have not been capitalized in the national accounts (nor on company balance sheets, for that matter) and are measured as intermediate inputs (or expenses). Following the pioneering work by Corrado, Hulten and Sichel (2005, 2009), internationally

[15] See Corrado and Jäger (2014) for a fuller explanation of the dataset, the sources-of-growth analysis and the econometric estimates on ICT externalities.

comparable estimates have been put together by the Intan-Invest project and discussed in Corrado, Haskel, Jonas-Lasinio and Iommi (2013). This work divides intangibles into three broad categories: (1) computerized information (software and databases), (2) innovative property (scientific R&D, design, financial innovations) and (3) economic competencies (workforce training, improvements in organizational structures, marketing and branding).

Table 4 shows that Europe (here the EU-15 aggregate, referring to the pre-2004 member states of the Union) shows a larger gap in terms of its level of investment in intangibles relative to market sector GDP than the United States.[16] The share of all measured intangible investment in value added for the market sector in the EU-15 has increased by 1 percentage point from 9.5 percent of market sector value added in the 1995-2002 period to 10.5 percent from 2008-2010, by which time it was about two thirds of the U.S. intangibles share in market GDP at 15.3 percent. While the intangibles intensity was below that of the U.S. in all categories, it was particularly weak in R&D and other innovative property, and market research and advertising. The former is in part related to the less intensive high-tech nature of Europe's manufacturing sector compared to the United States, whereas the latter has to do with a smaller share of distributional and personal services in the European economies relative to the United States. Within the EU-15, the Scandinavian countries, France and the UK have the highest intangibles intensity but even here the gap with the US remains significant. Many EU-15 countries currently invest less than half that in the US – these include Italy, Greece and Portugal (Corrado et al. 2013).

Table 4: Investment intensisty of intangible assets in the market sector as a percentage of market sector GDP for EU-15 economies, 1995-2010

	1995-2002	2003-2007	2008-2010
		European Union-15	
Computerized Information	1.4%	1.6%	1.8%
Scientific R&D	1.6%	1.7%	1.8%
Other Innovative Property	1.5%	1.7%	1.8%
Market Research & Advertizing	1.4%	1.3%	1.2%
Training	1.3%	1.3%	1.3%
Organisational Capital	2.2%	2.5%	2.7%
Total Intangible Capital	9.5%	10.0%	10.5%
		United States	
Computerized Information	1.9%	2.1%	2.3%
Scientific R&D	2.7%	2.6%	3.0%
Other Innovative Property	2.0%	2.7%	2.9%
Market Research & Advertizing	2.0%	2.1%	2.0%
Training	1.6%	1.8%	1.7%
Organisational Capital	3.1%	3.5%	3.4%
Total Intangible Capital	13.3%	14.7%	15.3%

Note: EU-15 refers to pre-2004 membership of the European Union

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

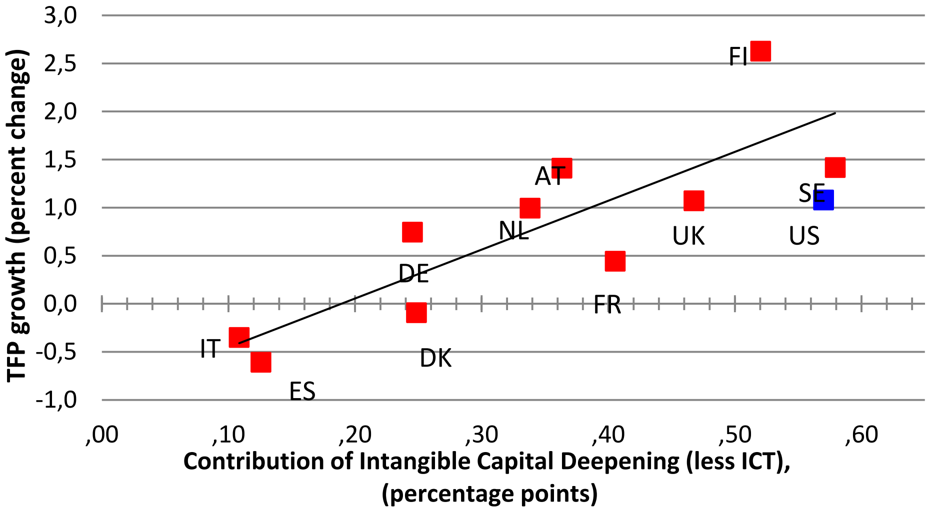
[16] The estimates refer to the 'market' economy, excluding education, health and public administration.

The United States saw a sharper increase than Europe in intangibles intensity, rising by 3 percentage points over the same period from 13.3 to 15.3 percent of market sector value added between 2001 and 2010. While the EU15 retained its intangibles during the recession, at least relative to value added, the U.S. lost almost 0.6 of a percentage point in 2009 but recovered it in 2010.

The division between the three main categories is fairly similar between the two main regions, but the US showed stronger growth over the entire period in all three asset types, and saw sharper increases especially in computerized information and economic competencies (especially organizational capital) during the late 1990s. The intensity of intangibles is in part related to the structure of the economy, which explains the relatively high intangible shares for the United Kingdom and the United States, which have large shares of GDP in service sectors. These economies have relatively large shares of their intangibles concentrated in economic competencies, notably organizational investments, and in ICT. In Germany, which has a share of GDP in manufacturing, the role of innovative property, including R&D, is relatively more important.

ICT, intangible assets and productivity 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 innovations across the economy, such as the re-organisation of production emphasized by Bertschek and Kaiser (2004) and Bresnahan, Brynjolfsson and Hitt (2002). It can also involve streamlining of existing business processes, for example order tracking, inventory control, accounting services, and the tracking of product delivery. At the same time, capital deepening in intangible assets also provides the foundation for ICT to impact on productivity. For example, the internal organisation of a firm plays a role in its ability to use ICT more efficiently, in particular through managerial and other organisational changes.

Chart 9 – Relationship between Intangible Capital Deepening and Total Factor Productivity Growth in EU Economies, 1995-2007



Note: Regression line is for the 10 EU countries only. Intangible capital excludes software.
Source: Corrado, Haskel, Jonas-Lasinio and Iommi (2013).

Going beyond complementarities between ICT and intangibles, **Chart 9** 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., 2013). 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).

Of course productivity spillovers from intangible capital are not automatic. For example, spillovers might be hampered if intangible capital is protected by intellectual property rules (copyright, trademarks, etc.) or lack of market scale to fully leverage the spillovers. Hence there are important policy implications when focusing more strongly on an investment agenda driven by intangible assets.

Even beyond a broader investment concept, other business practices may also help productivity. One line of research has found that about a quarter of cross-country and within-country TFP gaps can be accounted for by management practices. 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. Towards Closing Europe's Growth Gap

While, over the past six years, the economic policy agenda in Europe has been dominated by the need for stabilization of financial markets, an improvement in macroeconomic conditions and a return to lower unemployment rates, the need to close Europe's growth gap relative to its own pre-recession performance, as well as relative to the U.S. performance. Policy attention needs to shift to a more medium-term focus on reigniting growth, especially now that it turns out we may have entered a longer period of moderate growth, sometimes referred to a "secular stagnation" (Teulings and Baldwin, 2014).

Despite huge political challenges, there is no shortage of possible policy solutions to accelerate Europe's growth trend. The implementation of structural policy measures, ranging from more investment in hard and soft infrastructure to smarter regulation, more innovation and greater room for entrepreneurship, will hugely matter to improve structural conditions. The five headline targets set out in the Europe 2020 Agenda -- create more jobs, accelerate innovation, improve energy efficiency, strengthen education and reduce poverty exclusion – are fundamental components of any successful strategy to deliver positive social change and accelerate growth.

At face value, it makes much sense to direct our attention to investment as a key policy tool to revive growth, as is currently intended under the European Commission's Investment Plan. However, most of Europe's investment gap is related to private sector investment, requiring structural reforms that make markets function better across Europe (DIW, 2014).

In this report we have put much emphasis on the need to strengthen investment especially in the area of knowledge assets. Investments in intangible assets can drive innovation and organizational change. Such investments can create positive externalities to productivity. However, the productivity of investment and the way it translates into total factor productivity growth depends strongly on the ability to strengthen static effects (focused primarily on cost reductions and allocative efficiency) and dynamic effects (related to competition in product, labour and capital markets, and innovation) from a large single market in the European Union. Recent analysis shows that the creation of Single Digital Market and a single market for services across the European Union could contribute significantly to unleash the productivity gains from larger market size (van Ark, 2014; Mariniello et al, 2015).

The sluggish recovery in productivity suggests that medium-term factors are still predominant in explaining the productivity slowdown. The persistent shortfall in demand and an erosion of supply side factors as established by the long-term slowdown of potential output can be an important explanation for Europe’s growth gap. However, it also possible that there is a lull in the emergence of productive technology applications or that the negative productivity impact of the regulatory environment is playing a larger role than before the crisis. These factors significantly impact on the timing and speed of the productivity recovery.

References

Barnett, A., Batten, S., Chiu, A., Franklin, J. and Sebastia-Barriel, M. (2014) "The UK Productivity Puzzle", *Bank of England Quarterly Bulletin*, Q2

Bellmann, L., H-D. Gerner and M-C Laible (2015), "The German Labour Market Puzzle in the Great Recession," to be published in Ph. Askenazy, eds., *Productivity Puzzles in Europe*, CEPREMAP (http://www.cepremap.fr/depot/2015/ProductivityPuzzle/BellmannGerner.pdf)

Bertschek, I., and Kaiser, U. (2004), ' Productivity effects of organisational change: Microeconometric evidence', *Management Science*, 50(3): pp 394-404.

Black, S., E., and Lynch, L., M. (2001), 'How to Compete: The Impact of Workplace Practices and Information Technology on Productivity', *The Review of Economics and Statistics*, 83(3): pp 434-445.

Bresnahan, T. F., Brynjolfsson, E., and Hitt, L.M. (2002), 'Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence', *Quarterly Journal of Economics*, 117 (1): pp 339 – 376

Brynjolfsson, E., Hitt, L. M., and Shinkyu Yang (2002), 'Intangible Assets: Computers and Organisational Capital', *Brookings Papers on Economic Activity: Macroeconomics* (1): 137-199.

Corrado, C., Hulten, C. and Sichel, D. (2005), 'Measuring Capital and Technology: An Expanded Framework', *in* C. Corrado, J. Haltiwanger and D. Sichel, eds, *Measuring Capital in the New Economy*, University of Chicago Press, pp. 11–46.

Corrado, C., Hulten, C. and Sichel, D. (2009), 'Intangible Capital and US Economic Growth', *Review of Income and Wealth* **55**(3), pp. 661–685.

Corrado, C., J. Haskel, C. Jona-Lasinio and M. Iommi (2013), 'Innovation and Intangible Investment in Europe, Japan, and the United States', *Oxford Review of Economic Policy* 29 (2), 261–286

Corrado, C. (2011). *Communication Capital, Metcalfe's Law, and U.S. Productivity Growth*, Economics Program Working Paper (EPWP-2011-1), The Conference Board.

Corrado, C. and K. Jäger (2014), Communication Networks, ICT and Productivity Growth in Europe, *Economics Program Working Paper #14-04*, The Conference Board, New York.

Crafts, Nicholas (2010), *The Contribution of New Technology to Economic Growth: Lessons from Economic History*, Revista de Historia Economica, 28, 409-440.

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

Erumban A. and K. De Vries (2014), Projecting Global Economic Growth: The Conference Board Global Economic Outlook 2015, *Economics Program Working Paper #14-03*, The Conference Board, New York.

Greenstein, S. (2000). Building and delivering the virtual world: Commercializing services for internet access. *Journal of Industrial Economics* 48 (4), 391-411.

Hall, B. (2011), "Innovation and Productivity," Working Paper Series #2011-228, UNU-Merit, Maastricht.

Inklaar, R.C., M.P. Timmer and B. van Ark (2008), Market Services Across Europe and the U.S., *Economic Policy*, Vol. 23 (53), January, pp. 139–194.

Jorgenson, Dale W., Mun S. Ho, and Kevin J. Stiroh (2005), *Information Technology and the American Growth Resurgence*, Cambridge, MA: The MIT Press.

Mariniello, M. , A. Sapir, A. Terzi (2015) “The long road towards the European Single Market”, Bruegel working paper 2015/01

Piatkowski, M. (2013), Poland New Golden Age. Shifting for Europe’s Periphery to Its Center, *Policy Research Working Paper*, No. 6639, Washington D.C.

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

The Conference Board (2015), Productivity Brief 2015. *Global Productivity Growth Stuck in the Slow Lane with No Signs of Recovery in Sight*, May, New York.

Timmer, Marcel P., Robert Inklaar, Mary O’Mahony and Bart van Ark (2010), *Economic Growth in Europe. A Comparative Industry Perspective*, Cambridge University Press.

van Ark, Bart, Executive Editor (2011), *The Linked World: How ICT is Transforming Societies, Cultures and Economies*, The Conference Board, Report for Fundación Telefonica.

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

van Ark, Bart, Mary O’Mahony and Marcel Timmer (2008), “The Productivity Gap between Europe and the U.S.: Trends and Causes”, *Journal of Economic Perspectives*, Vol. 22 (1), Winter, pp. 25-44.

van Ark, Bart, Mary O’Mahony and Marcel P. Timmer (2013), “Europe’s Productivity Performance in Comparative Perspective: Trends, Causes and Recent Developments”, in M. Mas and R. Stehrer, eds. (2012), *Industrial Productivity in Europe, Growth and Crisis*, Edward Elgar Publishing, Inc., pp. 65-91.

Van Ark, Bart and Mary O’Mahony (2015), “Productivity Growth in Europe Before and Since the 2008/09 Economic and Financial Crisis “, in D.W. Jorgenson, K. Fukao and M.P. Timmer, eds., *Growth and Stagnation in the World Economy*, Cambridge University Press (forthcoming)

Appendix

Appendix Table 1a: Output, Hours and Labour Productivity Growth, and Growth Contributions by Major Input, log growth, 1999-2007

Average growth of 1999-2007				Contributions to GDP Growth From				
	Growth rate of GDP	Hours Worked[1]	Labour Productivity	Hours Worked (weighted) [2]	Labour composition	Non-ICT capital	ICT capital	Total Factor Productivity growth
	1		2	3	4	5	6	7
*EU-28**	*2.6*	*0.8*	*1.8*	*0.5*	*0.2*	*0.8*	*0.5*	*0.6*
*Euro Area***	*2.3*	*0.9*	*1.4*	*0.6*	*0.2*	*0.7*	*0.4*	*0.4*
*EU-15****	*2.4*	*0.9*	*1.5*	*0.6*	*0.2*	*0.7*	*0.5*	*0.4*
Ireland	5.9	3.3	2.6	1.8	0.4	2.4	1.0	0.4
Luxembourg	4.7	3.4	1.3	1.9	0.2	2.6	0.0	0.0
Greece	3.9	1.2	2.7	0.7	0.7	1.8	0.7	0.1
Spain	3.8	3.4	0.3	2.2	0.4	1.5	0.5	-0.8
Finland	3.5	1.1	2.4	0.7	0.1	0.4	0.8	1.5
Sweden	3.3	0.8	2.6	0.5	0.3	0.7	0.4	1.4
United Kingdom	3.0	0.7	2.3	0.5	0.4	0.7	0.7	0.7
Netherlands	2.5	0.9	1.6	0.6	0.2	0.4	0.5	0.8
Austria	2.5	0.6	1.9	0.4	0.2	0.5	0.4	1.0
Belgium	2.4	1.1	1.3	0.7	0.2	0.7	0.5	0.2
France	2.2	0.5	1.7	0.3	0.3	0.8	0.3	0.5
Denmark	2.0	0.7	1.3	0.5	0.1	0.5	0.7	0.2
Portugal	1.8	0.4	1.3	0.3	0.8	0.9	0.6	-0.9
Germany	1.6	0.0	1.6	0.0	0.0	0.3	0.3	1.0
Italy	1.5	1.0	0.4	0.7	0.2	0.7	0.2	-0.3
*EU-12*****	*4.4*	*-0.1*	*4.5*	*-0.1*	*0.3*	*1.2*	*0.8*	*2.2*
Latvia	7.6	-0.4	7.9	-0.2	0.2	5.1	0.0	2.5
Estonia	6.8	0.9	5.9	0.5	0.2	2.7	0.0	3.4
Lithuania	6.4	0.4	6.0	0.2	0.1	2.8	0.0	3.3
Romania	4.9	-1.7	6.6	-1.2	0.3	-0.2	0.7	5.3
Slovak Republic	4.9	0.1	4.7	0.0	0.2	1.1	1.0	2.5
Slovenia	4.3	0.6	3.7	0.4	0.7	1.4	0.6	1.3
Bulgaria	4.3	0.8	3.4	0.4	0.3	3.6	1.5	-1.5
Poland	4.1	0.1	4.0	0.0	0.3	0.9	0.7	2.3
Czech Republic	4.1	-0.4	4.5	-0.2	0.3	1.6	0.6	1.8
Cyprus	4.1	2.3	1.8	1.5	0.4	0.8	0.0	1.4
Hungary	3.6	0.1	3.5	0.0	0.5	1.1	1.5	0.4
Malta	3.0	0.6	2.4	0.4	0.0	0.8	0.0	1.8
United States	2.8	0.6	2.2	0.4	0.2	0.7	0.7	0.9

Note: countries are ranked by their GDP growth rate for 1999-2007

[1] refers to actual log growth rate of total hours worked

[2] refers to the contribution of total hours worked, weighted by the share of labor in total compensation, to the log growth

EU-28 excludes Croatia which became member of EU on 1 July 2013*

*Euro Area** refers to pre-2014 membership of 18 members, excluding Latvia which became a member on 1 January 2014*

*EU-15*** refers to pre-2004 membership of EU*

*EU-12*** refers to new membership of EU since 2004, and excludes Croatia which became member of EU on 1 July 2013*

Source: The Conference Board Total Economy Database™, May 2015, http://www.conference-board.org/data/economydatabase/

Appendix Table 1b: Output, Hours and Labour Productivity Growth, and Growth Contributions by Major Input, log growth, 2008-2014

Average growth of 2008-2014				Contributions to GDP Growth From				
	Growth rate of GDP	Hours Worked[1]	Labour Productivity	Hours Worked (weighted) [2]	Labour composition	Non-ICT capital	ICT capital	Total Factor Productivity growth
	1		2	3	4	5	6	7
*EU-28**	*0.2*	*-0.4*	*0.5*	*-0.2*	*0.2*	*0.5*	*0.3*	*-0.5*
*Euro Area***	*-0.2*	*-0.6*	*0.5*	*-0.4*	*0.2*	*0.3*	*0.3*	*-0.6*
*EU-15****	0.0	-0.3	0.3	-0.2	0.1	0.4	0.3	-0.6
Ireland	-0.3	-1.9	1.6	-1.2	0.2	0.8	0.6	-0.6
Luxembourg	0.9	0.5	0.3	0.3	0.2	2.0	0.0	-1.5
Greece	-4.3	-3.4	-0.9	-2.1	0.3	0.4	0.7	-3.6
Spain	-0.7	-2.4	1.7	-1.4	0.3	0.7	0.3	-0.6
Finland	-0.8	-0.5	-0.3	-0.3	0.2	0.2	0.9	-1.8
Sweden	0.8	0.6	0.2	0.4	0.1	0.5	0.7	-0.9
United Kingdom	0.6	0.7	-0.1	0.5	0.1	0.5	0.2	-0.8
Netherlands	0.0	-0.2	0.2	-0.1	0.1	0.3	0.2	-0.4
Austria	0.6	0.1	0.5	0.0	0.1	0.3	0.3	-0.1
Belgium	0.5	0.6	0.0	-0.1	0.2	0.4	0.5	-0.4
France	0.3	-0.1	0.4	0.0	0.2	0.6	0.1	-0.5
Denmark	-0.5	-0.7	0.2	-0.5	0.1	0.0	0.8	-0.8
Portugal	-0.9	-2.0	1.0	-1.3	0.6	0.1	0.7	-1.0
Germany	0.7	0.3	0.4	0.2	0.1	0.2	0.4	-0.2
Italy	-1.3	-1.2	-0.1	-0.8	0.1	0.0	0.1	-0.7
*EU-12*****	*1.5*	*-0.4*	*1.9*	*-0.3*	*0.2*	*1.1*	*0.7*	*-0.2*
Latvia	-0.8	-2.3	1.5	-1.3	0.1	0.9	0.0	-0.4
Estonia	-0.4	-1.9	1.5	-1.3	0.2	0.9	0.0	-0.1
Lithuania	0.6	-1.9	2.4	-1.1	0.2	1.3	0.0	0.1
Romania	1.1	-1.6	2.7	-1.0	0.2	0.6	0.1	1.2
Slovak Republic	1.8	0.1	1.7	0.0	0.1	0.7	1.5	-0.5
Slovenia	-0.6	-0.6	0.0	-0.5	0.3	0.3	0.7	-1.4
Bulgaria	0.9	-1.3	2.2	-0.7	0.3	2.3	1.3	-2.2
Poland	3.1	0.3	2.8	0.1	0.1	1.6	0.7	0.5
Czech Republic	0.3	-0.1	0.4	0.0	0.1	1.1	0.3	-1.2
Cyprus	-1.0	-1.6	0.6	-1.0	0.3	0.9	0.0	-1.2
Hungary	0.0	-1.0	1.0	-0.6	0.2	0.3	1.5	-1.5
Malta	2.2	1.4	0.8	0.8	0.2	-0.1	0.0	1.2
United States	1.1	0.0	1.2	0.0	0.1	0.3	0.4	0.3

Note: countries are ranked by their GDP growth rate for 1999-2007

[1] refers to actual log gorwth rate of total hours worked

[2] refers to the contribution of total hours worked, weighted by the share of labor in total compensation, to the log growth rate of

EU-28 excludes Croatia which became member of EU on 1 July 2013*

*Euro Area** refers to pre-2014 membership of 18 members, excluding Latvia which became a member on 1 January 2014*

*EU-15*** refers to pre-2004 membership of EU*

*EU-12*** refers to new membership of EU since 2004, and excludes Croatia which became member of EU on 1 July 2013*

Source: The Conference Board Total Economy Database™, May 2015, http://www.conference-board.org/data/economydatabase/

Appendix Table 2: Measures of Investment and Capital Growth and Intensity, Total, Non-ICT and ICT

	France	Germany	Italy	Spain	UK	Austria	Belgium	Finland	Netherlands	Sweden
Panel A	Total Investment-Output Ratio (real)									
1999-2007	11.5%	10.1%	14.4%	17.2%	12.3%	16.0%	12.6%	10.9%	12.4%	12.0%
2008-2014	12.8%	10.2%	13.1%	15.9%	12.7%	15.6%	14.3%	11.9%	12.4%	13.7%
	Non-ICT Investment-Output Ratio (real)									
1999-2007	9.9%	9.2%	13.1%	14.9%	9.2%	14.4%	10.9%	8.9%	10.1%	9.5%
2008-2014	10.1%	8.8%	11.3%	13.0%	8.8%	12.8%	10.6%	7.9%	9.3%	9.9%
	ICT Investment-Output Ratio (real)									
1999-2007	1.6%	0.8%	1.3%	2.2%	3.0%	1.6%	1.7%	2.0%	2.3%	2.4%
2008-2014	2.6%	1.4%	1.8%	2.9%	3.9%	2.6%	3.7%	4.0%	3.1%	3.8%
Panel B	Total Capital Stock, % growth									
1999-2007	2.4%	0.8%	2.2%	4.6%	3.3%	2.8%	2.5%	2.2%	1.5%	1.9%
2008-2014	1.8%	0.9%	0.2%	1.9%	2.3%	2.0%	2.1%	2.2%	1.1%	2.0%
	Non-ICT Capital Stock, % growth									
1999-2007	2.3%	0.7%	2.1%	4.4%	2.9%	2.7%	2.2%	1.6%	1.3%	1.6%
2008-2014	1.7%	0.4%	0.1%	1.7%	2.1%	1.9%	1.3%	1.1%	0.8%	1.3%
	ICT Capital Stcok, % growth									
1999-2007	6.4%	8.3%	5.2%	10.4%	10.8%	8.7%	11.6%	13.9%	8.2%	8.0%
2008-2014	4.0%	13.7%	4.6%	4.8%	4.5%	9.6%	12.0%	11.4%	5.0%	10.8%
Panel C	Total Capital-Output Ratio (real)									
1999-2007	1.45	1.49	1.69	1.66	1.13	1.90	1.33	1.51	1.61	1.52
2008-2014	1.59	1.46	1.90	2.01	1.28	1.93	1.43	1.64	1.62	1.55
	Non-ICT Capital-Output Ratio (real)									
1999-2007	1.41	1.47	1.65	1.59	1.05	1.86	1.29	1.43	1.55	1.46
2008-2014	1.54	1.41	1.84	1.90	1.18	1.87	1.33	1.46	1.53	1.44
	ICT Capital-Output Ratio (real)									
1999-2007	0.03	0.02	0.04	0.07	0.07	0.02	0.02	0.02	0.02	0.02
2008-2014	0.04	0.05	0.06	0.11	0.11	1.00	0.75	0.85	0.84	0.81
Panel D	Total Capital-Hour Ratio (real)									
1999-2007	85.4	86.3	85.2	73.9	52.1	95.7	84.7	75.0	96.1	79.9
2008-2014	99.7	90.7	95.9	98.1	63.8	107.4	95.3	88.2	103.2	89.4
	Non-ICT Capital-Hour Ratio (real)									
1999-2007	83.3	84.9	83.0	70.9	48.7	93.7	82.0	71.4	92.7	76.6
2008-2014	97.0	87.7	92.9	92.5	58.5	103.9	88.6	78.2	97.7	82.9
	ICT Capital-Hour Ratio (real)									
1999-2007	2.0	1.3	2.1	3.0	3.4	2.0	2.7	3.6	3.5	3.3
2008-2014	2.8	3.0	3.0	5.6	5.3	3.5	6.7	9.9	5.5	6.6

Source: The Conference Board Total Economy Database, May 2015

EUROPEAN ECONOMY DISCUSSION PAPERS

European Economy Discussion Papers can be accessed and downloaded free of charge from the following address:
http://ec.europa.eu/economy_finance/publications/eedp/index_en.htm

Titles published before July 2015 under the Economic Papers series can be accessed and downloaded free of charge from:
http://ec.europa.eu/economy_finance/publications/economic_paper/index_en.htm

Alternatively, hard copies may be ordered via the “Print-on-demand” service offered by the EU Bookshop: http://bookshop.europa.eu.

HOW TO OBTAIN EU PUBLICATIONS

Free publications:

- one copy:
  via EU Bookshop (http://bookshop.europa.eu);

- more than one copy or posters/maps:
  - from the European Union's representations (http://ec.europa.eu/represent_en.htm);
  - from the delegations in non-EU countries (http://eeas.europa.eu/delegations/index_en.htm);
  - by contacting the Europe Direct service (http://europa.eu/europedirect/index_en.htm) or calling 00 800 6 7 8 9 10 11 (freephone number from anywhere in the EU) (*).

(*) The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you).

Priced publications:

- via EU Bookshop (http://bookshop.europa.eu).

KC-BD-15-006-EN-N

Publications Office