EUROPEAN CENTRAL BANK

EUROSYSTEM

ECB FORUM ON CENTRAL BANKING

26-28 June 2017 • Sintra Portugal

Investment and growth in advanced economies

Conference proceedings

Contents

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ISSN 2363-3239 (pdf)
ISBN 978-92-899-2638-6 (pdf)
DOI 10.2866/7866 (pdf)
EU catalogue No QB-BN-17-001-EN-N (pdf)

Programme

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18:30 **Opening reception and dinner**

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Mario Draghi, President, European Central Bank

Dinner hosted by the Executive Board of the European Central Bank

Dinner speech
When Growth Is Not Enough
Ben Bernanke, Distinguished Fellow in Residence, Brookings Institution

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Mario Draghi, President, European Central Bank

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Is there an investment gap in advanced economies? If so, why?
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(with **Robin Döttling**, University of Amsterdam, and **Germán Gutiérrez**, New York University)

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Mariana Mazzucato, Professor, University College London
Joel Mokyr, Professor, Northwestern University
Hal Varian, Chief Economist, Google
Reinhilde Veugelers, Professor, KU Leuven, and Bruegel

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18:30 Reception and dinner

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Sources and mechanisms of stagnation and impaired growth in advanced economies
Robert Hall, Professor, Stanford University

Discussant: **Gauti Eggertsson**, Professor, Brown University

On the interaction between monetary policy, corporate balance sheets and structural reforms
Philippe Aghion, Professor, Collège de France
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Enisse Kharroubi, Senior Economist, Bank for International Settlements)

Discussant: **Charles Jones**, Professor, Stanford University

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Chair: **Vítor Constâncio**, Vice-President, European Central Bank

Agnès Bénassy-Quéré, Professor, Paris-Sorbonne University
Marco Buti, Director General Economic and Financial Affairs, European Commission
Sergei Guriev, Chief Economist, European Bank for Reconstruction and Development
Simon Johnson, Professor, Massachusetts Institute of Technology

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Mark Carney, Governor, Bank of England
Mario Draghi, President, European Central Bank
Haruhiko Kuroda, Governor, Bank of Japan
Stephen Poloz, Governor, Bank of Canada

Moderator: **Karnit Flug**, Governor, Bank of Israel

18:30 Dinner hosted by the Banco de Portugal


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Investment and growth in advanced economies – selected takeaways[1]

By Vítor Constâncio[2], Philipp Hartmann[3] and Peter McAdam[4]

The European Central Bank's 2017 Sintra Forum on Central Banking built a bridge from the currently strengthening recovery in Europe to longer-term growth issues for and structural change in advanced economies. Here we highlight some of the main points from the discussions, including what the sources of weak productivity and investment are and what type of economic polarisation tendencies the new growth model seems to be associated with.

This year's ECB Sintra Forum on Central Banking focused on the major real economy developments that surround and interact with monetary policy. Policymakers, academics and market economists debated on the topics of innovation, investment and productivity as well as business cycles, growth and associated policies. In this introductory chapter we summarise six of the main themes that were keenly discussed in Sintra in June 2017: explaining the global productivity slowdown; the implications of technical progress for employment; explaining the laggard post-crisis recovery; sources of weak investment; the complementarity between demand and supply policies; and relevant aspects of the broader societal context. Video recordings of all sessions are on the ECB's YouTube channel.

1 Explaining the productivity slowdown: techno-pessimism, fading research effort or mismeasurement?

"Perhaps the most remarkable fact about economic growth in recent decades is the slowdown in productivity growth that occurred around the year 2000," said Chad Jones (2017) in his discussion of the Aghion, Farhi and Kharroubi's (2017a) chapter. This phenomenon, which has affected many advanced economies, has been widely argued for a number of years and may have become more pronounced following the financial crisis (e.g. OECD 2015, Adler et al. 2017). Jones suggests studying the sources of this slowdown via the two main forces that explain productivity in modern growth theory: innovation and the misallocation of production factors. Regarding the latter, Jones (2017) reports key results of the literature that associates the dispersion of marginal products of the same factors across firms in the US and in Europe with

1 This selective summary of the discussions at the 2017 ECB Sintra Forum on Central Banking was first published on VoxEU on 23 August 2017. Any views expressed are those of the authors and do not necessarily reflect those of the European Central Bank or the Eurosystem.

2 Vice-President, ECB.

3 Deputy Director General Research, ECB.

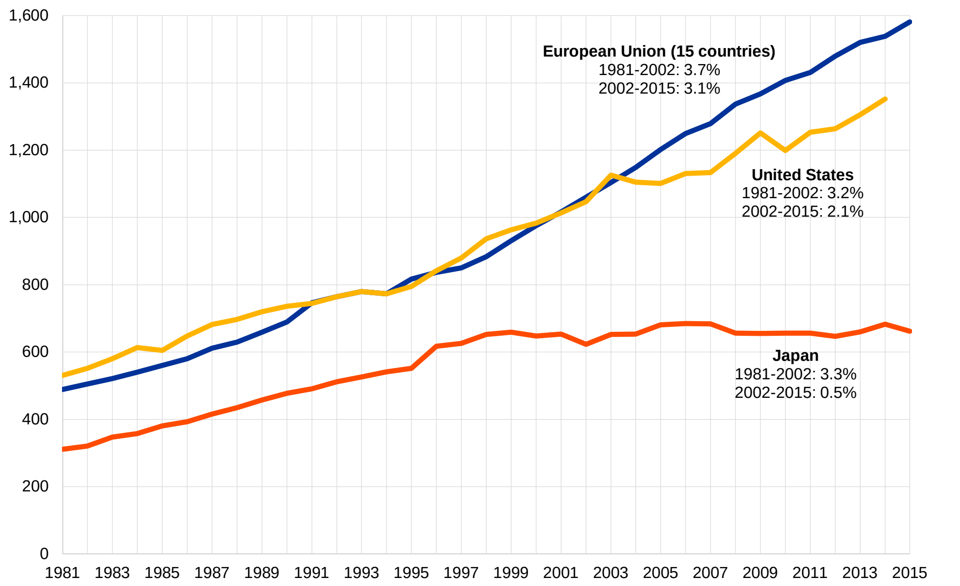
4 Principal Economist, ECB.

degrees of misallocation (e.g. Gopinath et al. 2017, highlighting deteriorating factor allocation in Italy and Spain). A recent paper by Bils et al. (2017) suggests, however, that if one corrects for measurement error, the entire increase of allocative inefficiency in US manufacturing since the late 1970s disappears. It may therefore be advisable to wait until measurement errors are also accounted for in the literature on non-manufacturing sectors and on Europe before drawing clear-cut conclusions.

Regarding innovation Jones argues that their contribution can either be driven by the impact of new ideas and processes on total factor productivity ("ideas TFP") or the research effort pushing new ideas (such as the number of researchers employed). Gordon (2016), for example, suggested for the US that ideas with the same productivity benefits are harder to discover today than in history. Jones – in joint work with Bloom, Van Reenen and Webb (2017) – finds that this is a rather general phenomenon across different sectors and products, detecting significant reductions in "ideas TFP". Over many decades, however, this was compensated by over-proportionate increases in research effort. As research employment growth has slowed down since the early 2000s – mostly in Japan, significantly in the US and to a lesser extent in the European Union (see Figure 1) – the phenomenon has become more harmful today than it used to be. This can explain the productivity slowdown and is consistent with Gordon's thesis. But it puts the emphasis on ways on how to maintain a sufficiently high research effort.

Figure 1

Development of research efforts



Note: The lines show the logarithms of the total number of researchers (in 1,000s), so that their slopes reflect growth rates. The text insertions show average annual growth rates for two sub-periods, respectively.
Source: Reproduced from Jones (2017), Chart 4, who uses OECD Main Science and Technology Indicators.

On historical grounds, Joel Mokyr (2017) challenged in his Sintra contribution the view that it is the nature of today's innovations that accounts for the productivity slowdown and staged a forceful rebuttal of "techno-pessimism". First, economists' primary measures of innovation – estimations of total factor productivity and counting of patents – both underestimate their productivity effects. Second, in history humans have overcome the fact that the technological fruits that can still be picked are hanging higher and higher through building “taller and taller ladders”. This “arboreal metaphor” illustrates a feedback from technology to science. The technological tools detected over centuries that made that possible included the telescope, the microscope, the eudiometer or, more recently, x-ray crystallography. Two prominent and powerful tools today are laser technology and computers. The “hot technology of the day” is machine learning – according to Hal Varian (2017) – and quantum computing is on the way. So, Mokyr does not see why the growth in economic welfare should slow down for technological reasons. In this context, it was interesting that an online poll showed that 72% of voting Sintra participants felt that the productivity gains from the ICT (information and communication technology) revolution will accelerate, given that its full potential has not emerged yet. Reinhilde Veugelers (2017) added that it is diffusion that makes innovation such a powerful growth engine. She referred to recent evidence produced by the OECD suggesting that the diffusion and adoption of the latest technology across firms may be more of a problem than a lack of innovation as such (Andrews et al. 2015). (This point had already been much emphasised by Mario Draghi and Catherine Mann at the 2015 ECB Sintra Forum; see Constâncio et al. 2015.) She reckoned that the most potent mechanism for the transfer of new know-how is when the innovating researchers move from frontier firms to other sectors or firms.

In addition to Mokyr, several other Sintra speakers also considered measurement problems affecting productivity assessments, e.g. through the underestimation of GDP (the numerator of aggregate productivity measures). Jones (2017) and Varian (2017) referred to software or services provided for free or at very low prices by ICT firms or not-for-profit institutions (e.g., Facebook, Google or Wikipedia). The problems are particularly pronounced in areas involving rapid quality change, such as photography, the global positioning system (GPS) or, more generally, the smartphones in which these and many other applications are embedded. At zero or near-zero prices, hedonic quality adjustments in nominal national accounts are difficult. Recent literature, such as Byrne et al. (2016) or Syverson (2017), however, argues that the “free” services and other ICT features only account for a small part of the productivity slowdown in the US. Based on the practice of statistical agencies to impute value developments of disappearing products from value developments of surviving products, Philippe Aghion presented in Sintra sizeable growth underestimation for France and the US, amounting to slightly more than half a percentage point of measured annual growth (see Aghion et al. 2017b for the US). But Jones (2017) points out that the authors do not find a substantial change over time, which would be required to provide an explanation for the measured productivity slowdown around 2000.

All this led to a debate about the relative roles of the private and the public sector in innovation. Reinhilde Veugelers (2017, Chart 1) showed that the European Union is particularly weak in business research and development (R&D; constituting only about 1% of GDP) relative to major advanced and emerging economies, having even fallen behind China over the last decade. Chad Jones (2017, Chart 3) showed that after large contributions in the late 1950s and 1960s, government R&D has become much less important in US intellectual property investments over the last decades. This evidence led Simon Johnson (2017) to identify the government as “a primary culprit” for the US losing its world technological leadership and the growth and employment that went along with it. He called for increased public spending on basic scientific research and the creation of new technology clusters, based on local expertise and specialisation, and co-funded by the federal government. Mariana Mazzucato promoted mission-directed government investments in innovation (one example being the US Apollo programme of the 1960s and early 1970s), which “co-shape and co-create markets” and benefit from patient long-term strategic financing (Mazzucato and Semieniuk 2017). She was sceptical of indirect forms of financing, such as tax advantages, which may enhance profits without necessarily ensuring “additionality”. Dietmar Harhoff (2017) concurred that the preferential treatment of intellectual property, such as “patent boxes”, amounted to beggar-thy-neighbour policies with little positive impact on innovation.

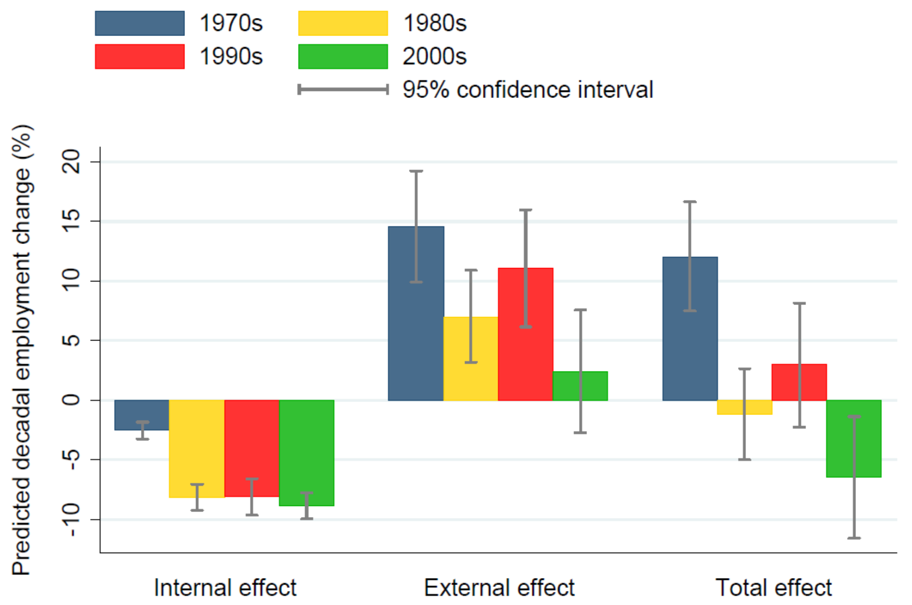
2 Does technical progress create or destroy jobs?

One of the fundamental tenets of growth theory, underlined by the discussion summarised in the previous section, is that technical progress makes long-term per capita growth possible in equilibrium (Solow 1956, 1957). But recently concerns have arisen that the technical advances of our times may be particularly destructive in replacing jobs (the dystopian variant of techno-pessimism, according to Joel Mokyr (2017)). David Autor and Anna Salomons (2017) forcefully argue that this has not been the case in history, despite such concerns having emerged periodically over the last 200 years. Covering 19 advanced economies between 1970 and 2007, they find that productivity growth has been mildly positive for aggregate employment. Their country-industry panel regressions suggest that – over long periods of time – the negative effect of productivity growth on employment in the same industry is more than compensated by positive “spillovers” in terms of expansions in other industries. Thus, structural change triggered by technical progress, ultimately, creates more employment in new sectors than it destroys in old ones.

Does this pattern change over time? Figure 2, taken from Autor and Salomons’ (2017) chapter in this volume, compares the estimated own (“internal”) industry effects, the external effects on (or spillovers to) other industries and the net effects for four different decades. In line with the pooled results, the internal effects are consistently negative and the external effects consistently positive. In the 2000s, however, the positive external effects are so small that the net effects turn negative. Whether this means a reversal of the historical pattern is open to debate. The authors indicate that as early as in the 1980s negative and positive effects were basically cancelling each other out but strong positive spillovers returned in the 1990s. Moreover, preliminary follow-up work with a different database going up until 2014 seems to suggest that another recovery of the benign productivity-employment relationship may have emerged (though these results could be subject to change). Ultimately, only the future will tell. Indeed, another online survey showed that participants of the Sintra Forum were divided on this issue. 43% of voters indicated that technological innovation will have an insignificant impact on employment in the next 10 years. 28% felt that the net impact would be positive and an equal share that it would be negative.

Figure 2

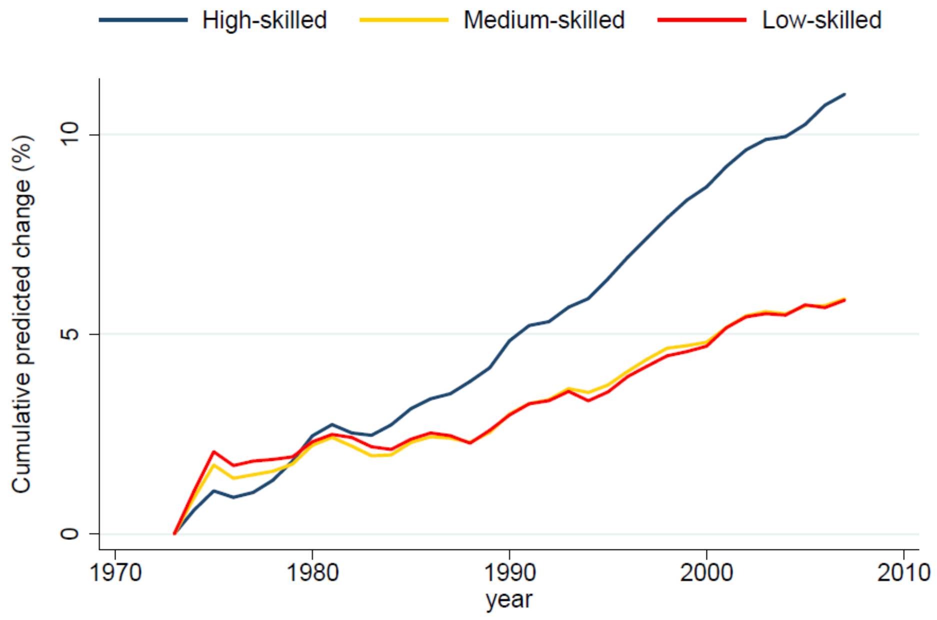
Effects of productivity on employment



Note: The bars show cumulative percentage employment changes for four sub-periods as predicted by productivity growth in five sectors (utilities, mining and construction; manufacturing; education and health; high-tech services; and low-tech services) from estimating equation (7) in Autor and Salomons (2017) as reported in their Table 8. "Internal effect" describes the effect of industry productivity changes on employment in the same industries. "External effect" describes the effect of industry productivity changes on employment in all other industries. "Total effect" is the net effect of these two. The sample comprises 19 industrial countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, the United Kingdom, the United States, Japan, South Korea and Australia) and covers, for most of the countries, the period between 1970 and 2007. Productivity is gross output per worker. Predictions for the 1970s and 2000s are scaled up to be comparable to the 1980s and 1990s.
Source: Reproduced from Autor and Salomons (2017), Figure 7.

Interestingly, the historical productivity-employment nexus is quite different across sectors. For example, the strongest positive employment spillovers originate from productivity growth in low-tech services (capturing e.g. car sales, real estate, hotels and catering or social and personal services). Significantly positive spillovers also emerge from high-tech services (e.g. telecommunication and financial intermediation) as well as health and education. Autor and Salomons do not find significant external effects of other sectors. More worrying, however, are their results on the effects of productivity growth on the composition of labour demand. They find clear evidence of "polarisation" in the group of 19 advanced economies in that most new jobs were – on average – created for highly skilled employees, whereas jobs for medium or low-skilled workers grew slowly (see Figure 3).

Figure 3
Effects of productivity on employment by skill group



Note: The lines show cumulative average changes in employment shares for three skill groups as predicted by productivity growth in the same five sectors as listed in the note to Figure 2 from estimating equation (8) in Autor and Salomons (2017) as reported in their Table 9. The sample comprises the same 19 industrial countries as listed in the note to Figure 2. Productivity is gross output per worker.
Source: Reproduced from Autor and Salomons (2017), Figure 8.

3 Explaining the slow post-crisis recovery: demand or supply?

While slower productivity advances may have been weighing on economic growth since the early 2000s, it cannot explain why recoveries towards potential growth were so weak and slow. Bob Hall (2017) tries to identify sources of stagnation tendencies in his Sintra chapter by looking at developments in real earnings per member of the population in six major advanced economies (France, Germany, Italy, Spain, the United Kingdom and the United States) between 2000 and 2014. He regards this as a particularly suitable metric, because it measures the well-being of a majority of populations. In the seven years following the start of the financial crisis, Germany in particular but also France appear to have experienced little stagnation, with positive annual growth rates of labour earnings. The most stagnating economies were Italy and Spain with negative annual growth rates of almost 2%, whereas the UK and the US saw more moderate stagnation.

Hall suggests assessing the plausibility of factors explaining stagnation tendencies by decomposing real earnings per capita into seven components (the labour share of total income, multifactor productivity, the capital-output ratio, hours per worker, the employment rate, the labour-force participation rate and the ratio of working-age population to total population). Table 1, taken from his chapter in this volume, shows the annual growth rates for five of these components between 2007 and 2014. First of all, the many green (favourable, mostly positive values) cells in the first row illustrate the relatively positive developments for German workers. Second, the declining labour share in total income (see first column "Share") is a broad-based international problem, which Hall characterised as "the hot topic in quantitative macroeconomics". (Not only is it present in the US, many European countries and Japan but also in China; see Karabarbounis and Neiman (2014), Figures II and III, and Hall 2017, Figure 2). Third, protracted unemployment weighs particularly on labour earnings in Southern Europe ("Employment rate" column). The primary stagnation factor in France is the labour share while in the UK it is productivity. Finally, the single red (negative value) cell in the last column ("Participation") suggests that declining labour market participation is a problem that is very much in evidence in the US.

Table 1

Development of stagnation factors after 2007

	Share	Productivity	Hours/ week	Employment rate	Participation
Germany	0.28	0.50	-0.11	0.66	0.37
Spain	-1.50	-0.17	-0.60	-3.26	0.05
France	-0.93	0.01	-0.38	-0.40	0.07
Italy	-1.04	-0.80	-0.67	-1.23	0.12
UK	-0.35	-0.52	-0.16	-0.17	0.07
US	-0.85	0.85	-0.26	-0.27	-0.85

Note: Numbers in the cells show the average annual growth rates of five components of real labour earnings per member of the population between 2007 and 2014. "Share" stands for the labour share of total income, "Productivity" for multifactor productivity, "Hours/week" for weekly hours per worker, "Employment rate" for the share of workers in the labour force and "Participation" for the share of people of working age in the total population. Green cells highlight favourable growth rates (usually positive) and red cells unfavourably large negative growth rates. The strength of the colour reflects the degree to which the respective growth rate is favourable or unfavourable.
Source: Reproduced from Hall (2017), Table 9.

From the large diversity across countries and labour income components, Hall (2017) finds it implausible that "unitary theories" of stagnation can explain these empirical facts. Rather, each country seems to have its own story, involving particular patterns of factor shares, productivity growth, unemployment, labour supply and demographics. Moreover, many of the key factors are not of a cyclical nature and therefore cannot be effectively cured with expansionary monetary policy. Instead, some of them belong to supply components, such as labour participation or productivity, to which policy attention should turn, in Hall's view.

In his discussion of Bob Hall's chapter, Gauti Eggertsson (2017) challenged this, based on a different reading of the facts. Referring to a host of previous papers, he argued that New Keynesian secular stagnation theory can make a valuable contribution to understanding the slow post-crisis recovery. First, the financial crisis may have involved an aggregate demand shock that lowered the real natural rate of interest, so that the effective lower bound of interest rates prevented central banks from exercising enough monetary policy stimulus. The resulting low inflation and growth in the euro area, the UK and the US would go hand-in-hand with sub-par labour income growth. Second, the effect of the crisis may have been asymmetric in the euro area, with Germany being less negatively affected. So, the common ECB monetary policy may have been consistent with the full utilisation of labour inputs in Germany, in Eggertsson's view, but insufficiently expansionary for Italy or Spain.

Third, Eggertsson was not convinced that divergent labour market or productivity outcomes could not be explained by demand factors as well. For example, different labour market institutions could lead to different degrees of "labour rationing" across countries. Moreover, if innovation is endogenous hysteresis effects of a demand-led recession could lead to a protracted slowdown in productivity (e.g. Garga and Singh 2016).

An online survey suggested that 36% of voting Sintra participants thought that mostly aggregate demand and 18% that mostly declining supply trends were responsible for the slow economic recovery. Interestingly, 38% pointed to a protracted debt overhang that affects deleveraging and demand. The relatively favourable labour income developments in Germany prompted several Sintra participants to offer their own explanations. Volker Wieland explained that the phenomenon started before the financial crisis, around 2005, when the lagged effects of previous massive tax reductions, labour market reforms and a focus of the unions on job security rather than wage growth healed Germany's economy – at the time "the sick man of Europe". Thereafter, Germany developed a low-wage services sector that hurt productivity through a composition effect but at the same time greatly expanded employment. In other words, it was an example of a supply-side policy that created demand, supporting Bob Hall's conclusions. In a similar vein, Michael Burda added that Germany increased labour force participation via part-time work arrangements. Since total hours worked hardly changed, this acted like work sharing. There was an increase in wage dispersion but little movement in wage levels. Workers had to accept this due to the labour market reforms, which cut unemployment benefits and their duration, and thereby increased incentives through replacement rates (the ratio of unemployment income and expected income when employed). All not a miracle, Burda said, just neoclassical economics working the right way.

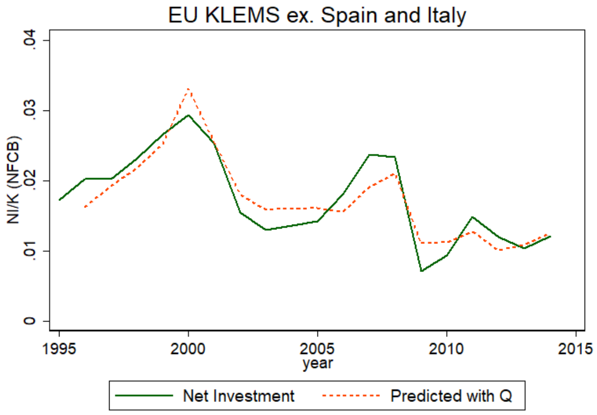
4 Investment gap? The roles of product market competition and intangibles

One of the distinct features of the deep and long recession caused by the twin (financial and sovereign debt) crises and the slow recovery in Europe has been weak investment. Thomas Philippon, in collaboration with Robin Döttling and Germán Gutiérrez (2017b), explored the causes of this phenomenon, comparing primarily a group of eight euro area countries with the United States. They first establish a number of stylised facts: 1) the corporate investment rate was low in both the euro area and the US, with the share of intangibles (investment in intellectual property such as computer software and databases or research and development) increasing and the share of machinery and equipment decreasing; 2) corporate profits were low in the euro area and relatively high in the US; 3) Tobin's Q (e.g. Tobin 1969) was relatively low in the euro area – explaining corporate investment well (in particular if one excludes Italy and Spain) – and relatively high in the US but underpredicting investment there. The latter finding – that there is an "investment gap" at the aggregate level in the US but not in Europe – is displayed in Figure 4, where in the upper panel the dashed red line tracks investment rather well and in the lower panel investment is lower than what Q would predict.

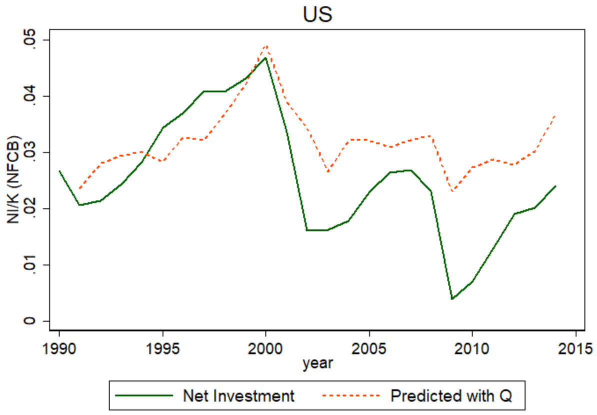
Figure 4

Explanation of investment with Tobin's Q

Panel a. Austria, Belgium, Finland, Germany and the Netherlands



Panel b. The United States



Note: The lines in both panels show the measured net investment rate of the non-financial corporate sector and the net investment rate predicted by a regression of net investment on the lag of Tobin's Q. The vertical axis is in fractions. Net investment is measured as gross fixed capital formation scaled by the lagged stock of fixed assets ("gross investment rate") minus gross fixed capital consumption (i.e. depreciation). Tobin's Q is measured as the market value of equity plus total liabilities minus financial assets divided by the sum of the stock of produced and non-produced assets (which includes tangible and intangible capital). The "euro area" in Panel a. comprises only five countries for data limitations and since Italy and Spain have been excluded because the relationship between investment and Q is different for them.
Source: Reproduced from Döttling, Gutiérrez and Philippon (2017), Chart 11.

As is well known, Tobin's Q is defined as the market value of a firm's assets (typically measured by its equity price) divided by its accounting value or replacement costs. Under certain assumptions, it should capture the main economic fundamentals determining investment. Therefore, Döttling, Gutiérrez and Philippon (2017b) infer from fact 3) above that weak aggregate demand and low expected future growth must explain the low Q in the euro area, which in turn explains most of the aggregate euro area investment slump (notably in Austria, Belgium, Finland, France, Germany and the Netherlands, but not in Italy or Spain). In contrast, the general economic environment as reflected in a high Q does not explain weak US investment, which must be due to other, more structural factors. Building on previous work (Gutiérrez and Philippon 2016), the authors observe that the opening of the aggregate investment gap in the US around 2000 coincides with the start of a trend in corporate concentration and a reduction in antitrust enforcement in the country. (Regulatory reforms in many euro area countries, however, made their product markets more competitive during the 2000s.) Moreover, given high corporate savings (see fact 2) above; see also Eberly 2017, Chart 2), it is not plausible that financial constraints played a large role in the US (except perhaps at the height of the financial crisis). Finally, the share of intangibles in investment is unlikely to explain the difference between the US and the euro area, because its growth was slowing in the early 2000s (see e.g. Eberly 2017, Chart 1, or Jones 2017, Chart 3) and Europe's share catching up since the late 1990s (Döttling et al, 2017b, Chart 15). In sum, Philippon et al. conclude that deteriorating product market competition is likely to be a major factor in explaining the aggregate US investment gap. But structural features, probably other than corporate concentration, also seem to be of relevance in explaining the investment gaps in Italy and Spain. There is no comparable corporate concentration trend in Europe, but Reinhilde Veugelers (2017) observed that research and development (R&D) expenditures become more concentrated in fewer firms. It needs to be determined whether this R&D concentration is simply a sign of the advantages that leading technological firms may have in terms of efficiency; or whether it may in fact become an obstacle not only to the diffusion of ideas but also to new entrants in the future.

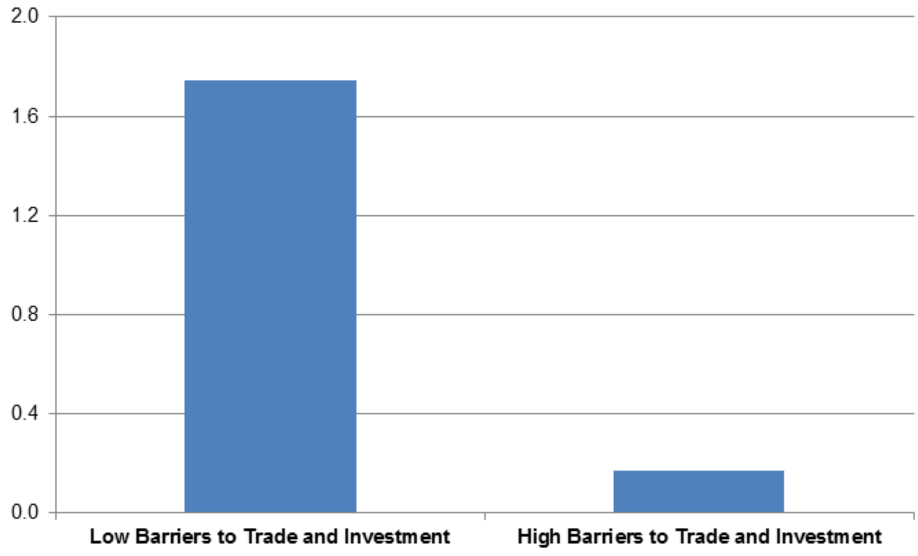
As several Sintra authors elaborated, intangibles generally play an increasing role in investment. This is particularly a consequence of the prominent role that digitisation, information and communication technology play in what is often called the third industrial revolution. But in the US a pronounced trend started as early as in the 1950s (see Eberly 2017, Chart 1, and Jones 2017, Chart 3). Once the fixed costs of IT hardware have been paid, human capital and intellectual property gain importance relative to physical capital. This can affect investment and its determinants in various ways. First, as Philippon et al. suggest, intangible assets are more difficult to accumulate quickly, which is tantamount to higher adjustment costs. So, in equilibrium, rising intangible investment should lead to rising Q. Second, Enrico Perotti pointed out that high-intangibles firms pay highly skilled employees to invest their human capital (e.g. to develop software) and therefore do not need to undertake as much traditional investment spending as low-intangibles firms (see Döttling et al. 2017a). In fact, the investment share of some of the most innovative and rapidly growing sectors in the US, namely the high-tech industries, is rather stagnant (Eberly 2017, Chart 3). Third, intangible investments are beset with measurement problems, so that they could be underestimated in available data. All in all, the negative relationship between the share of intangibles and total investment that emerges from this list is consistently confirmed in empirical estimations (Eberly 2017), including (for cross-sectional industry data) in Europe (Döttling et al. 2017b). So, part of the low investment observed in countries with rapidly growing intangible shares, such as the euro area countries covered in Döttling et al., may not be a sign of economic weakness but a sign of structural change and difficulties in capturing intangible investment in available data. But growing intangibles could still be a contributing factor to labour market polarisation, because the employees producing them tend to be highly skilled and paid (see also the discussion of Autor's and Salomons' paper above).

5 Relationships between demand and supply policies

The Sintra discussions about the slow post-crisis recovery and the role that investment played in it suggest that both supply and demand policies have a role to play, depending on the country and time considered. But demand and supply policies do not need to be substitutes: they can be complements. Philippe Aghion, in a joint chapter with Emmanuel Farhi and Enisse Kharroubi (2017a), crystallised this with the example of monetary policy and product market reforms, bolstering President of the ECB Mario Draghi's (2014) view that "aggregate demand policies will ultimately not be effective without action in parallel on the supply side". With two different empirical approaches they find that countercyclical interest rate movements become more effective in stimulating output when product markets are more competitive. The first approach starts by estimating the countercyclicality of real short-term interest rates (for the euro area, the area-wide nominal rate divided by national inflation rates) in response to output gaps at the level of 14 advanced economies (9 euro area countries, 3 other EU countries, and Australia and Canada). The second step of this approach is to interact the estimated countercyclicality parameters with measures of firm financial constraints and product market regulation. As long as the 1998 level of the OECD indicator for barriers to trade and investment is low, it turns out in a country-industry panel regression of quarterly data between 1999 and 2005 that a sector with high labour costs to sales (as a measure of firms' financial constraints) located in a country with high interest rate countercyclicality exhibits a 1.6 percentage points higher real value-added per worker growth than a sector with low labour costs to sales in a country with low interest rate countercyclicality (see the left blue pillar in Figure 5). In contrast, when product market regulation is heavy, then this growth difference evaporates (right pillar in the figure).

Figure 5

Joint effects of the countercyclicality of interest rates and corporate financial constraints on labour productivity for different degrees of product market competition



Notes: The blue bars show the estimated effects of the responsiveness of real short-term interest rates to output gaps ("countercyclicality of interest rates") and financial constraints in corporate sectors on labour productivity in 14 advanced economies (excluding the US benchmark, they are Australia, Austria, Belgium, Canada, Germany, Denmark, Spain, Finland, France, the UK, Italy, the Netherlands, Portugal and Sweden) between 1999 and 2005. The countercyclicalities of interest rates are estimated for each country in separate regressions (and reported in Figure 1 of Aghion et al. (2017)). These country elasticities are then inserted in a cross-country cross-industry panel estimation of productivity in which they are interacted with the ratio of labour costs to sales in the corresponding US industry (as a measure of financial constraints) and a dummy variable for the OECD indicator of barriers to trade and investment (in 1998 as an inverse measure of product market competition; see Aghion et al. (2017), Table 1). Labour productivity is real value-added per worker growth. The two bars show the change in labour productivity in response to a joint change from the first quartile to the third quartile in the industry distribution of financial constraints and from the first to the third quartile in the country distribution of the estimated countercyclicalities of interest rates, once for high (low barriers) and once for low product market competition (high barriers). The vertical axis is in percentage points.
Source: Reproduced from Aghion, Farhi and Kharroubi (2017a), Figure 2.

The second approach takes the ECB's announcement of its Outright Monetary Transactions programme (OMT) in September 2012 as a laboratory. It first estimates forecast errors for 10-year government bond yields of 7 euro area countries (Austria, Belgium, France, Germany, Italy, Portugal and Spain) for the periods 2011-12 and 2013-14, i.e. before and after the OMT announcement. The difference between the two is taken as surprise changes in firms' funding costs. Stressed countries, such as Italy and Spain, experienced sharp unexpected interest rate drops but the same did not apply to other countries, such as France or Germany. Then a difference-in-difference estimation of industry growth rates for 2013-14 for the 7 countries on industry growth rates for 2011-12, corporate indebtedness (measured in 2010 and 2012, respectively) and interactions between corporate indebtedness, product market regulation (same OECD indicator as in the first approach but for 2013) and the estimated OMT interest rate surprises is conducted. The results suggest that heavily indebted corporate sectors grew faster as a consequence of the large surprising interest reductions, but only when they were located in countries with relatively less regulated product markets. This effect works primarily via short-term debt, which firms can adjust more quickly than long-term debt. It may, however, be attenuated by an uncompetitive banking sector.

Marco Buti (2017) addressed the relationship between demand and supply policies from a fiscal policy angle. He juxtaposed two views on the relationship between fiscal consolidation and structural reforms, one where they are substitutes (e.g. because the temporarily unemployed from labour market reforms would have to be supported) and another where they are complements (e.g. because expansionary demand policies diminish governments' incentives for introducing politically costly structural reforms). Buti showed recent European evidence supporting the latter view. Before the crisis there was no clear relationship between primary cyclically adjusted budget balances and reductions in employment protection. But with the sovereign debt crisis a positive relationship emerged (see his Chart 2). He argued, however, that the complementary approach may not be the right model for the future, because of rising inequality and fiscal consolidation leading to reduced public education spending and the reforms that are most needed, i.e. the ones stimulating innovation and productivity, having significant budgetary costs.

6 When growth is not enough: inequality and the greater societal context

Introduced by a haunting plea from Ben Bernanke (2017) in his chapter "When growth is not enough", some of the Sintra discussions branched out to distributional issues and the societal context that influences the environment in which central bankers, much like other policymakers, act and economic policies are conducted. Bernanke stressed that the continuing structural change when the unusually prosperous post-WWII period in the US "normalised" as of the 1970s was not accompanied by supportive labour market and social policies. Over time, popular dissatisfaction about the economic situation emerged related to stagnating earnings per worker, declining social and economic mobility, social dysfunctions such as drug abuse and distrust of political institutions. Rectifying the situation requires interventionist policies, such as community re-development, infrastructure spending, job training and addiction programmes. For Europe, Bernanke recommended that the continuing labour market reforms that are necessary should be accompanied by training and other work force development; that structural reforms should be accompanied by demand policies; and that political legitimacy should be ensured through subsidiarity. Whilst against the background of ever faster technical progress and structural change it was relatively uncontroversial that the traditional "once-in-a-lifetime schooling strategy" has to give way to continuous updating of knowledge and skills ("lifelong learning"), Dietmar Harhoff (2017) warned that so far there is little systematic implementation and institutional development.

Sergei Guriev (2017, Chart 1) presented "elephant curves" (à la Milanovic 2016), suggesting that the crisis recession acted in a regressive way in southern European countries (see also Buti 2017, Chart 3), whereas in other euro area countries asset price declines implied that the recession's cost were mostly borne by the better-off. But in terms of popular support for economic policies, Guriev (2017, Table 1) provided evidence that it is not inequality per se but perceived "unfair" inequality (defined as uneven opportunities, such as parental background, gender, ethnicity or place of birth) that leads to the rejection of a market economy (and also corruption). Other factors captured in the residuals of the estimation, such as lack of effort or bad luck, do not have this effect.

Agnès Bénassy-Quére (2017) perceived an imbalance in Europe between trade and competition policies being centralised at the area-wide level but social and tax policies being left at the national level. When the federal level promotes free trade and competitive markets, then Member States are left to bear the social consequences. In her view Member States could be better empowered by coordination in tax and social policies. One idea is to make the EU's Globalisation Adjustment Fund more effective; another is to introduce US-style TTTTs (timely, temporary, and targeted transfers).

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AND GROWTH
ECONOMIES

When Growth Is Not Enough

Dinner speech by Ben S. Bernanke[5]

I'd like to thank Mario and the European Central Bank for inviting me to participate in the conference here in Sintra. I'm a civilian now of course, but it's good once again to see friends and acquaintances from my days as a member of the community of central bankers.

The theme of the conference, investment and growth in advanced economies, has about it a feeling of transition, which I suspect was intended. With policy interest rates at or close to zero in most advanced economies, and with inflation still very low, there is much more work to be done before a full recovery from the global financial crisis can be claimed. Still, with cyclical expansions apparently entrenched, financial conditions looking stable, and the major central banks at least contemplating their exits from extraordinary policies, it's natural that the focus is beginning to shift to the longer-term challenges of growth, investment, and structural change.

In my remarks this evening I'll discuss some of these longer-term challenges from the perspective of my own country, the United States. My talk is entitled "When Growth Is Not Enough" and is strongly influenced by recent political developments, which have cast a bright light on some disturbing economic and social trends in the United States. Unfortunately, policymakers in recent decades have been slow to address or even to recognize those trends, an error of omission that has helped fuel the voters' backlash. If the populist surge we are seeing today has an upside, it is to refocus attention on both the moral necessity and practical benefits of helping people cope with the economic disruptions that accompany growth. Of course, Europe also faces the problems of managing change as it pursues an agenda of reform and growth. In the last portion of my remarks I will offer a few thoughts on the implications of the U.S. experience for Europe.

Regarding the United States, let me start with the positive. The nation's cyclical recovery is entering its ninth year this month and appears to have room to run. Although the Great Recession was exceptionally deep and the recovery was slower than we would have liked, real GDP is now up about 12.5 percent from its pre-crisis peak, and real disposable income is up more than 13 percent. Importantly, the Federal Reserve is close to meeting its congressionally mandated goals of maximum employment and price stability: since the trough in employment in early 2010, more than 16 million net new jobs have been created — compared to a civilian labor force of about 160 million — bringing the unemployment rate down from 10 percent to well below 5 percent. Indeed, the latest reading on unemployment, 4.3 percent, is the lowest since 2001. Inflation is below but relatively close to the Fed's 2 percent target. The Federal Open Market Committee has expressed confidence that recent softness

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in inflation is transitory and that wage and price inflation will continue to strengthen; on this, of course, the data will be dispositive.

As is often the case in the United States, the household sector is a major driver of the expansion. Real wages and labor income have lagged the improvement in labor market conditions but appear to be moving in the right direction. Households have very substantially de-leveraged since the crisis and household wealth, reflecting the recoveries in house prices and equity values, exceeds the pre-crisis peak by about 20 percent in real terms. Consumer sentiment has rebounded to pre-crisis levels, with high proportions of respondents expressing confidence in their own financial prospects.

Beyond the cyclical recovery, optimists can also point to some strong longer-term fundamentals for the American economy. It remains, of course, a highly-integrated continental economy with a large domestic market and free internal movement of goods, capital, and labor. The federal government provides a national fiscal policy, including substantial risk-sharing across geographic regions, and (mostly) unified regulation, including of the financial sector. Despite recent controversies and talk of border walls, immigrants are generally well-assimilated, and their presence contributes to an overall demographic outlook in the United States that is somewhat better than in most other advanced economies. The country remains a technological leader, with vibrant high-tech clusters like Silicon Valley and a large share of the world's leading research universities within its borders. The markets for capital and labor are generally flexible, and the financial system looks healthy. Energy production has soared as the result of the application of new technologies. These are substantial advantages.

And yet, despite the sustained cyclical upswing and the country's fundamental strengths, Americans seem exceptionally dissatisfied with the economy, and indeed have been for some time. For example, those who tell pollsters that the country is "on the wrong track" consistently outnumber those who believe that America is moving "in the right direction" by about two to one.[6] And, of course, last November Americans elected president a candidate with a dystopian view of the economy, who claimed that the "true" U.S. unemployment rate was 42 percent, (inaccurately) described the United States as the most highly taxed nation in the world, and promised to restore lost American greatness. Nor, it should be noted, did the anger come exclusively from the right, as a left-wing populist made a serious bid for his party's nomination as well.

So why, despite the undoubted positives, are Americans so dissatisfied? The reasons are complex and not entirely economic. Without trying to be comprehensive, I'll highlight here four worrying trends that help to explain the sour mood.

[6] A Reuters/IPSOS poll conducted in early June asked survey respondents: 'Generally speaking, would you say things in this country are heading in the right direction, or are they off on the wrong track?' 57% answered that that the country is 'on the wrong track', while only 28% said that the country was moving 'in the right direction'.

First, stagnant earnings for the median worker. Since 1979, real output per capita in the United States has expanded by a cumulative 80 percent, and yet during that time, median weekly earnings of full-time workers have grown by only about 7 percent in real terms. Moreover, what gains have occurred are attributable to higher wages and working hours for women. For male workers, real median weekly earnings have actually declined since 1979.[7] In short, despite economic growth, the middle class is struggling to maintain its standard of living.

Second, declining economic and social mobility. One of the pillars of America's self-image is the idea of the American Dream, that anyone can rise to the top based on determination and hard work. However, upward economic mobility in the United States appears to have declined notably over the postwar period. For example, in a paper aptly entitled "The Fading American Dream", Raj Chetty and coauthors (2016) studied one metric of upward mobility, the probability that a child would grow up to earn more than his or her parents. Using Census data, they found that 90 percent of Americans born in the 1940s would go on to earn more as adults than their parents did, but that only about 50 percent of those born in the 1980s would do so. Other research finds that the United States now has one of the lowest rates of intergenerational mobility among advanced economies, measured for example by the correlation between the earnings of parents and their children (Corak 2013). For a supposedly classless society, the U.S. is doing a good job of rigidifying its class structure through means that include residential and educational segregation, social networking, and assortative mating (Reeves 2017).

Stagnant median wages and declining mobility are of course related to the overall trend toward increased income and wealth inequality, which is already more pronounced in the United States than in other advanced economies.[8] In particular, high inequality tends to impede economic mobility, by increasing the relative educational and social advantages of those in the upper percentiles. (My former Princeton colleague Alan Krueger (2015) has dubbed the close cross-country relationship between inequality and lack of social mobility the Great Gatsby curve.) I think though that the frustrations of stagnant earnings and limited upward mobility are more salient to most Americans than inequality per se. Americans tend to be more tolerant of inequality than citizens of other countries, putting greater stress on equality of opportunity rather than equality of outcome (Isaacs 2016).

The third adverse trend is the increasing social dysfunction associated with economically distressed areas and demographic groups. For example, other former Princeton colleagues of mine, Anne Case and Angus Deaton (2017), have done important work on morbidity and mortality among white working-class Americans (more precisely, people with only a high school degree). They find that midlife mortality rates among white working-class Americans have sharply worsened,

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[7] Data are from the Bureau of Labor Statistics' Current Population Survey (CPS) through the first quarter of 2017, tracking median usual weekly real earnings for wage and salary workers employed full-time, 16 years and older (seasonally-adjusted). Real earnings for men fell by 2% over the period, while real earnings for women rose by almost 25%.

[8] According to the World Bank, the United States has the highest Gini coefficient of the G7 industrial countries.

relative to other U.S. demographic groups and working-class Europeans. Case and Deaton refer to the excess mortality among the white working class as “deaths of despair,” because of the associated declines in indicators of economic and social well-being and the important role played by factors like opioid addiction, alcoholism, and suicide. Indeed, in 2015, more Americans died of drug overdoses — about 60 percent of which involved opioids — than died from auto accidents and firearms-related accidents and crimes combined.[9]

Because the white working class was pivotal in the recent election, its problems have received much attention recently. However, the problem of social dysfunction among the economically stressed population is much broader. For example, among the most worrying economic trends is the decline in labor force participation among prime-age (25-54) men, which has occurred across demographic groups. In 1960, about 97 percent of American prime-age men were in the labor force; today, only about 88 percent are. Studies find that many of the men not working in the formal sector are substantially idle — not involved in caring for children or the elderly, for example (Black et al., 2016). Participation rates of prime-age men are lower in the United States than in many European countries, despite the weakness of labor markets in much of Europe.[10] One possible explanation for the trans-Atlantic divergence is differences in criminal justice policies. America’s high incarceration rate leaves many men, particularly African-American men, with prison records, which hurts their employment opportunities for many years after release.

The fourth and final factor I’ll highlight, closely tied to the others, is political alienation and distrust of institutions, both public and private. In particular, Americans generally have little confidence in the ability of government, especially the federal government, to fairly represent their interests, let alone solve their problems. In a recent poll, only 20 percent of Americans said they trusted the government in Washington to do what is right “just about always” or “most of the time” (Pew 2017). The failure to prevent the global financial crisis did not help this situation of course, but these attitudes are long-standing, going back at least to the 1970s. A recent book by the sociologist Arlie Russell Hochschild (2016), *Strangers in Their Own Land*, recounts her experience living for several years in a politically conservative community in Louisiana. One of her most striking findings is the reluctance of Louisianans to support federal efforts to protect the local environment, despite the substantial health risks they face as the result of pollution by oil refineries and other industries. This opposition appears to be partly a product of traditional values of self-reliance and independence but also reflects deep-seated skepticism about the sincerity of government officials and their ability to achieve improvements at a reasonable economic cost.

Stagnant median wages, limited upward mobility, social dysfunction, and political alienation are a toxic mix indeed. How did it happen? The sources of these adverse

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9 According to the Center for Disease Control, in 2015 52,404 people died from drug overdoses in the United States. 33,091 of those deaths involved opioids. In comparison, 35,092 people died in auto accidents in 2015 (Department of Transportation), and 12,195 people died from non-suicide firearm-related injuries in 2014 (CDC, 2015 data not yet available).

10 According to the OECD, in 2016 the prime-age (25-54) male labor force participation rate was 88.5% in the United States. For the United Kingdom, Germany, France, Spain and Italy, the participation rates for this demographic were 92.3%, 92.0%, 92.7%, 92.5%, and 88.2% respectively.

trends are complex and interrelated. But at a fifty-thousand-foot level, they appear to be the product of some broad global developments of the postwar era, together with the U.S. policy response (or lack thereof) to those developments.

The immediate postwar era, say 1945-1970, was an extraordinary period, economically speaking. Following fifteen years of depression and war, Americans were once again able to enjoy peace and prosperity. A substantial backlog of technological and commercial innovations was available to be exploited, and producers faced enormous pent-up demand for consumer goods and housing. The federal government provided expansive support for education, through the GI Bill for example, and undertook major infrastructure projects like the interstate highway system. Importantly, for a time the U.S. economy had no effective competition, either from war-ravaged Europe and Japan or from not-yet-emerging markets. There was plenty of economic change and what we would now call disruption, but strong catch-up growth, active economic policies, and America's monopoly position resulted in widely shared economic gains. It's not really surprising that the period evokes nostalgia as a time of national greatness.

However, as Robert J. Gordon (2016) has documented, the pace of technological and economic change in the middle of the past century was historically quite unusual and unlikely to be sustained. By 1970 or so, the backlog of commercial and technical opportunities available at the end of the war had been used up, and the conversion to a civilian, consumer-driven economy was complete. Outside of a brief productivity spurt associated with the IT revolution, the past forty-five years or so have been historically more 'normal' in terms of economic growth and productivity gains. Productivity growth has been particularly anemic over the past decade. Equally important, American economic dominance faded, as Europe and Japan recovered and as what we now call emerging-market economies accounted for increasingly larger shares of global output and trade. The emergence of China as a global trading power was particularly disruptive, with adverse effects on the wages and employment opportunities of many American workers of moderate or lower skills (Autor et al., 2016). In contrast, high-skilled workers tended to be favored by global economic integration, particularly those whose talents were scalable to the size of the market, such as managers of internationally active firms or of global hedge funds.

Of course, similar forces were playing out in Europe and elsewhere, with effects that depended on the policy response. In the United States, in the immediate postwar era, feelings of social solidarity and economic optimism had helped to generate political support for significant expansions in government spending on education, health, and infrastructure. The introduction of Medicare and expanded Social Security benefits provided economic security for the elderly in particular. However, the postwar glow faded as America divided over a variety of big issues in the 1960s and 1970s, including the Vietnam War and the civil rights movement, and as economic growth began to slow. The Reagan revolution heralded a more constrained approach to economic policy, aimed primarily at fostering aggregate economic growth by empowering the private sector. Examples of such policies include tax cuts and tax reform under Reagan, a number of consequential trade agreements under Reagan's immediate successors, financial deregulation and welfare reform under Clinton, and more tax cuts and trade opening under the second President Bush.

Missing from the mix, however, was a comprehensive set of policies aimed at helping individuals and localities adjust to the difficult combination of slower growth and rapid economic change. Why policy was not more proactive in this area is an interesting question: perhaps the failures of Lyndon Johnson's Great Society and the inflationary monetary and fiscal policies of the 1960s and 1970s hurt the reputation of activist policies and helped revive American's laissez-faire inclinations. Perhaps the stresses in the heartland were not sufficiently understood until it was too late. Perhaps the politics didn't align. Whatever the reason, it's clear in retrospect that a great deal more could have been done, for example, to expand job training and re-training opportunities, especially for the less educated; to provide transition assistance for displaced workers, including support for internal migration; to mitigate residential and educational segregation and increase the access of those left behind to employment and educational opportunities; to promote community redevelopment, through grants, infrastructure construction, and other means; and to address serious social ills through addiction programs, criminal justice reform, and the like. Greater efforts along these lines could not have reversed the adverse trends I described at the outset — notably, Europe, which was more active in these areas than the United States, has not avoided populist anger — but they would have helped. They might also have muted the disaffection and alienation which our political systems are currently grappling.

Which brings us to the present. Whatever one's views of Donald Trump, he deserves credit, as a presidential candidate, for recognizing and tapping into the deep frustrations of the American forgotten man, twenty-first-century version. That frustration helped bring Trump to the White House. Whether the new president will follow through in terms of policy, however, is not yet clear. Trump's economic views, which mirror the odd combination of factions that make up his coalition, are a somewhat unpredictable mixture of right-wing populism and traditional supply-side Republicanism. The policies that his administration has actually proposed or endorsed so far lean toward the latter, including health care bills that would significantly reduce insurance coverage among lower-income people, tax cuts for both individuals and corporations, and a relaxation of financial, environmental, and other regulations. Policies that would more directly address the needs of the people who elected Trump, such as community redevelopment, infrastructure spending, job training, and addiction programs have recently received a good bit of rhetorical attention from the White House, but it remains to be seen whether that attention will be translated into programs and budgets. Ironically, it may be that the most rhetorically populist president since Andrew Jackson will, in practice, not be populist enough.

I'm hardly the first to observe that Trump's election sends an important message, which I've summarized this evening as: sometimes, growth is not enough. Healthy aggregate figures can disguise unhealthy underlying trends. Indeed, the dynamism of growing economies can involve the destruction of human and social capital as well as the creation of new markets, products, and processes. Unaided, well-functioning markets can of course play a crucial role in facilitating economic adjustment and redeploying resources, but in a world of imperfect capital markets and public goods problems there is no guarantee that investment in skills acquisition, immigration, or regional redevelopment will be optimal or equitable. Tax and transfer policies can help support those who are displaced, but the limits on such policies include not only traditional concerns like the disincentive effects of income-based transfers but also conflicts with social norms. Notably, people can accept temporary help but transfers that look like “handouts” are often viewed with extreme suspicion or resentment. Some active interventions thus seem a necessary part of a responsive policy mix.

Providing effective help to people and communities that have been displaced by economic change is essential, but, on the other hand, we should not understate how difficult it will be. Addressing problems like the declining prime-age participation rate or the opioid epidemic will require the careful and persistent application of evidence-based policies which populist politicians, with their impatience and distrust of experts, may have little ability to carry through. Moreover, to be both effective and politically legitimate, such policies need to involve considerable local input and cooperation across different levels of government as well as cooperation of the public and private sectors. The credibility of economists has been damaged by our insufficient attention, over the years, to the problems of economic adjustment and by our proclivity toward top-down, rather than bottom-up, policies. Nevertheless, as a profession we have expertise that can help make the policy response more effective, and I think we have a responsibility to contribute wherever we can.

I’ve been speaking about the United States, but of course Europe has shared some of the same problems, including populist reactions. The European Central Bank, as one of the most respected European-wide institutions, has been an outspoken proponent of pro-growth reforms. I think the ECB’s efforts have generally been constructive, and reforms have taken place and appear to have had some success, including here in Portugal. I’d like to conclude my remarks with a few comments about the European reform process, in light of the American experience.

First, I have made the case this evening for more intervention in labor markets by American policymakers, for example, through active workforce policies like the promotion of job training and apprenticeships. In Europe, however, the message has been that governments should intervene less in labor markets. I’d emphasize that there is no real contradiction here; rather, the contrast reflects differences in starting points. It’s useful to divide labor market interventions into what I will call, somewhat tendentiously, forward-looking and backward-looking policies. Forward-looking policies, like job training and other types of workforce development, aim to help workers adjust to change, endowing them with the skills and training they need to take advantage of new opportunities. To invoke another theme of this conference, forward-looking policies generally involve investment in human, social, or physical capital. Backward-looking policies, in contrast, aim to preserve the status quo, and in particular to protect incumbent firms and workers. Examples are rules that excessively restrict employers’ ability to fire workers or to set pay and hours, impose restrictive licensing or certification requirements, or create large fixed costs of hiring or market entry. Backward-looking policies inhibit productive growth and change, which is why they are ultimately not sustainable. Relative to the United States, and reflecting differences in political traditions among other factors, postwar Europe has employed many more of both the forward-looking and backward-looking types of labor market policies. Calls for reform in Europe today largely focus, appropriately, on the elimination of backward-looking policies. But the distinction between the two types of policies should be in front of mind, including the recognition that a reduction in rules that protect incumbent workers, for example, may need to be balanced with an increase, not a decrease, in active policies to support necessary adjustments in the labor market.

Second, the cyclical recovery in the United States is sufficiently far advanced that issues of longer-term growth and reform can be debated largely independently of short-term cyclical considerations. In Europe, labor market slack remains, interest rates are still at zero, and macroeconomic adjustment is incomplete, all of which implies that reform plans cannot ignore macroeconomic conditions. A small literature has argued that structural reforms can be counterproductive when interest rates are at the zero lower bound, because of disinflationary effects (Eggertsson et al., 2014). I tend to agree that those ZLB effects are probably quantitatively modest (Vogel 2014). However, whether rates are at zero or not, it seems quite likely that policies that have the effect of releasing redundant labor resources could have adverse short-run effects if insufficient aggregate demand exists to re-employ those resources in a reasonable time. It's consequently important for the content and sequencing of reforms to take into account the macroeconomic situation, as has been pointed out by the International Monetary Fund (2016) and others. Likewise, reforms can complement, but should not be viewed as a substitute for, appropriate macroeconomic policies. In particular, labor market reforms should not by themselves be expected to solve national competitiveness problems, at least not in the short term. Also needed are appropriate macroeconomic policies, especially fiscal policies, to help ensure adequate demand and remedy the underlying source of trade imbalances.

Finally, on both sides of the Atlantic we have to grapple with the issue of political legitimacy. As I've noted, in the United States, many voters have gone beyond disagreement about specific policy proposals to question both the federal government's motives and its capacity to improve their lives. Winning back that trust will require a better policy process as well as better policies. In particular, we need more two-way communication between the grass roots and the center, to try to adapt policy initiatives to local conditions. America's federal system, in which much economic policy is made at the state and local level, could help that happen.

In Europe, again, the starting point for policy is different. While the United States is already an integrated continental economy, Europe is still working toward that goal. Achieving uniformity across the euro zone in areas such as banking and capital market regulation inevitably requires decisions to be made at the center, even if after wide consultation. However, there may be less of a need for top-down uniformity in other areas, such as in the regulation of labor markets or small businesses. Accommodation of national and sub-national differences in rules and institutions that mostly affect local conditions could foster more responsive and more effective policies, which could also be perceived as politically more legitimate.

To sum up: generally speaking, economic growth is a good thing, positively associated with many indicators of citizens' well-being. More-rapid growth also improves fiscal balances, giving governments greater capacity and flexibility. But, as recent political developments have brought home, growth is not always enough. Economic growth almost always involves significant change and the possibly rapid depreciation of some human and social capital. The resulting dislocations can be very difficult to address, likely requiring a mix of top-down, bottom-up, public, and private interventions. But if the resources released by economic change are to be effectively redeployed; if the benefits of growth are to be widely shared; and if economic policy is to be widely perceived as both successful in its own terms and politically legitimate, then making those interventions effective should be a top priority for policymakers.

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ECB
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Accompanying the economic recovery

Introductory speech by Mario Draghi
President of the ECB

For many years after the financial crisis, economic performance was lacklustre across advanced economies. Now, the global recovery is firming and broadening. A key issue facing policymakers is ensuring that this nascent growth becomes sustainable.

Dynamic investment that drives stronger productivity growth is crucial for that – and in turn for the eventual normalisation of monetary policy.

Investment and productivity growth together can unleash a virtuous circle, so that strong growth becomes durable and self-sustaining and, ultimately, is no longer dependent on a sizeable monetary policy stimulus.

The discussions we will have over the next two days – in particular understanding the puzzles of slowing productivity growth and persistently low investment – are therefore highly relevant for the path of the economy and of our monetary policy.

Yet as we anticipate the problems of tomorrow, we must also work on the issues of today. For central banks, this means addressing an unusual situation. We see growth above trend and well distributed across the euro area, but inflation dynamics remain more muted than one would expect on the basis of output gap estimates and historical patterns.

An accurate diagnosis of this apparent contradiction is crucial to delivering the appropriate policy response. And the diagnosis, by and large, is this: monetary policy is working to build up reflationary pressures, but this process is being slowed by a combination of external price shocks, more slack in the labour market and a changing relationship between slack and inflation. The past period of low inflation is also perpetuating these dynamics.

These effects, however, are on the whole temporary and should not cause inflation to deviate from its trend over the medium term, so long as monetary policy continues to maintain the solid anchoring of inflation expectations.

Hence we can be confident that our policy is working and its full effects on inflation will gradually materialise. But for that, our policy needs to be persistent, and we need to be prudent in how we adjust its parameters to improving economic conditions.

1 Monetary policy is effective in raising demand

Understanding inflation dynamics requires us to divide up the inflation process into two legs: the effect of monetary policy on aggregate demand; and the effect of aggregate demand on inflation. All the evidence suggests that the first leg is working well.

Though the euro area recovery started later than those in other advanced economies, we have now enjoyed 16 straight quarters of growth, with the dispersion of GDP and employment growth rates among countries falling to record low levels. If one looks at the percentage of all sectors in all euro area countries that currently have positive growth, the figure stood at 84% in the first quarter of 2017, well above its historical average of 74%. Around 6.4 million jobs have been created in the euro area since the recovery began.

The role of monetary policy in this growth story is clear. Since mid-2014, our monetary policy stance has been determined by the combination of three instruments: first, low policy interest rates; second, asset purchases in financial markets and targeted long-term refinancing operations for banks; reinforced by, third, forward guidance on both.

This has created strong downward pressure on financing costs, with rates falling steeply across asset classes, maturities and countries, as well as across different categories of borrowers. Converging financing conditions have in turn fed into rising domestic demand.

According to our Bank Lending Survey, our latest easing phase has coincided with a strong rebound in demand for consumer credit to purchase durable goods, while demand for loans for fixed investment has gradually firmed. At the same time, falling borrowing costs have reduced interest payment burdens and facilitated deleveraging, which is one reason why, for virtually the first time since 1999, spending has been rising while indebtedness has been falling. This is a sign that the recovery may be becoming more sustainable.

Just to put our measures into context, since January 2015 – that is, following the announcement of the expanded asset purchase programme (APP) – GDP has grown by 3.6% in the euro area. That is a higher growth rate than in the same period following QE1 or QE2 in the United States, and a percentage point lower than the period after QE3. Employment in the euro area has also risen by more than four million since we announced the expanded APP, comparable with both QE2 and QE3 in the United States, and considerably higher than QE1.

For the monetary transmission process to work, however, stronger growth and employment ought to translate into higher capacity utilisation, scarcity in production factors and – in time – upward pressure on wages and prices. And this is what we see.

The unemployment gap – the difference between actual unemployment and the non-accelerating inflation rate of unemployment (NAIRU) – is narrowing and is forecast by the Commission to close within the next two years. Surveys of business capacity utilisation are now above their long-term average levels. And inflation is recovering. Between 2016 and 2019 we estimate that our monetary policy will have lifted inflation by 1.7 percentage points, cumulatively.

Yet the second leg of the inflation process – the transmission from rising demand to rising inflation – has been more subdued than in the past. How can this be explained?

The link between output and inflation is determined by three main factors: external shocks to prices; the size of the output gap and its impact on inflation; and the extent to which current inflation feeds into price and wage setting. In different ways, each of these factors has been relevant for the delayed reaction of inflation to the recovery.

2 Temporary external shocks

Starting with external factors, one explanation for the slow improvement in inflation dynamics is that we are still suffering the after-effects of price shocks in global energy and commodity markets, which have led output and inflation to move in different directions.

Inflation has indeed been subject to such shocks over recent years, most notably the oil and commodity price collapse in 2014-15. This not only depressed the cost of imported energy, but also lowered global producer prices more generally. ECB analysis suggests that the global component in the underperformance of euro area inflation in recent years was considerable. In 2015-16, around two-thirds of the deviation of euro area headline inflation from a model-based mean can be accounted for by global shocks linked to oil prices.

Even though the downward pressure on inflation from past oil price falls is now waning, oil and commodity prices are still having a dragging effect – if only because they continue to lack a clear upward trend. In fact, lower oil and food prices than those assumed in the March 2017 projections are an important factor behind the downward revision of our latest inflation forecasts.

Oil-related base effects are also the main driver of the considerable volatility in headline inflation that we have seen, and will be seeing, in the euro area.

Falling import prices partly explain the subdued performance of core inflation, too. This is because imported consumer products account for around 15% of industrial goods in the euro area. Likewise, changes in commodity prices feed through into some services items and into industrial goods produced with high energy intensity. As a result, in the first quarter of 2017, oil-sensitive items were still holding back core inflation. This illustrates that core inflation does not always give us a clear reading of underlying inflation dynamics.

Global factors therefore do appear to be weighing on the path of inflation today. But our analysis suggests that the drivers of low oil prices at present are mainly supply factors, which a central bank can typically look through.[11]

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[11] For a fuller account of the response of monetary policy to demand and supply shocks in the oil market, see Draghi M. (2015), "Global and Domestic Inflation", speech at Economic Club of New York, 4 December.

And even if supply factors affect the path of inflation for some time, with inflation expectations secure, they should not ultimately affect the inflation trend.

3 Uncertainty over slack and its impact on inflation

A second explanation for the discrepancy between real developments and inflation is uncertainty surrounding the size of the output gap and its impact on inflation. This might be happening for a variety of reasons.

One possible reason is that we are currently experiencing positive supply developments. In particular, we do observe that, as the recovery strengthens, the supply of labour is rising too. Labour force participation has been growing consistently over the last few years, buoyed especially by increases in participation rates of older workers. We also see some evidence that labour supply has become more elastic due to immigration, particularly in strongly growing economies such as Germany.[12]

Since 2007, the euro area participation rate has risen by around 1.5 percentage points, whereas in the United States it has fallen by more than 3 percentage points in the same period.[13]

Structural reforms in labour markets have been a factor in this labour supply boost.

Similarly, past reforms in product markets may also have had a positive effect on the supply side by reducing price mark-ups, increasing productivity and raising growth potential.

Another reason why there is some uncertainty over slack is the correct notion of unemployment – that is, there may be residual slack in the labour market that is not being fully captured in the headline unemployment measures. Unemployment in the euro area has risen during the crisis, but so too has the number of workers who are underemployed (meaning that they would like to work more hours) or who have temporary jobs and want permanent ones. This has implications for inflation dynamics, since these people might prioritise more hours or job security over higher wages in employment negotiations.

If one uses a broader measure of labour market slack including the unemployed, underemployed and those marginally attached to the labour force – the so-called "U6" – that measure currently covers 18% of the euro area labour force.[14]

Phillips curve models that employ this measure appear to be more successful in predicting inflation.[15]

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12 Deutsche Bundesbank (2016), "The Phillips curve as an instrument for analysing prices and forecasting inflation in Germany", *Monthly Report*, April.

13 Source: AMECO database (workers aged 15-74 for the euro area and 16-74 for the United States).

14 ECB (2017), "Assessing labour market slack", Box 3, *Economic Bulletin*, Issue 3.

A third reason why slack might be larger is the effect of so-called “global slack”. This is the notion that globalisation has made labour supply characteristics more uniform across the globe and labour markets more contestable. Conditions in foreign labour markets could therefore have a dampening effect on domestic inflation even as domestic slack is shrinking.

The evidence, however, is not clear-cut. For example, new ECB analysis finds only limited support for the thesis that global slack is weighing on euro area inflation today, over and above the impact it has on global prices.[16]

Alongside the question of the level of slack is the impact of slack on inflation. This is the well-known debate on the slope of the Phillips curve. There are indeed reasons to believe that wage and price-setting behaviour in the euro area might have changed during the crisis in ways that slow the responsiveness of inflation.

For example, structural reforms that have increased firm-level wage bargaining may have made wages more flexible downwards but not necessarily upwards.

Likewise, we see today that firms are absorbing input costs through lower margins due to uncertainty over future demand, which would also tend to temper price pressures. Indeed, ECB estimates show that, if we take into account the unusually large and persistent shocks of the past years, the Phillips curve for core inflation may well be somewhat flatter recently. However, insofar as the slope of the Phillips curve depends nonlinearly on the cyclical position, it may steepen again when the economy reaches and surpasses full potential.

While these various reasons might delay the transmission of our monetary policy to prices, they will not prevent it. As the business cycle matures, the higher demand resulting from positive supply developments will accelerate price pressures, while firms’ pricing power will increase and the broader measures of slack will converge towards the headline measures.

As shown in the United States, the gap between the headline unemployment rate and those broader measures typically opens in recessions and shrinks in expansions. Currently, it is converging to the minimum levels recorded before the 2001 and 2007 recessions.

So just as for oil and commodity price shocks, we can be reasonably confident that the forces we see weighing on inflation are temporary – so long as they do not feed more lastingly into inflation dynamics.

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[15] See Cœuré, B. (2017), “Scars or scratches? Hysteresis in the euro area”, speech at the International Center for Monetary and Banking Studies, Geneva, 19 May.

[16] ECB (2017), “Domestic and global drivers of inflation in the euro area”, *Economic Bulletin*, Issue 4.

4 Low inflation feeding into price and wage setting

This brings us to the third possible explanation for why growth might be diverging from inflation: the hypothesis that a persistent period of low inflation is in fact feeding into price and wage setting in a more persistent way.

What is clear is that our monetary policy measures have been successful in avoiding a deflationary spiral and securing the anchoring of inflation expectations. In the past, as interest rates approached zero, some did question our ability to add sufficient accommodation to combat a prolonged period of too-low inflation. We answered those doubts by demonstrating that we would take any measures necessary within our mandate to deliver our mandate, and that those measures were effective in further easing financial conditions. Deflation risk premia, which had been growing in 2014 and 2015, have now been more or less priced out of market-based inflation expectations.

That being said, a prolonged period of low inflation is always likely to be exacerbated by backward-lookingness in wage and price formation that occurs due to institutional factors, such as wage indexation.

This has plainly happened in the euro area. ECB analysis finds that, compared with long-term averages, low past inflation dragged down wage growth by around 0.25 percentage points each year between 2014 and 2016.

The evidence as to whether backward-lookingness has increased recently is mixed. There were signs that indexation had fallen in the early part of the crisis, and ECB empirical estimates suggest that the weight of past inflation in current inflation has decreased. Yet there is also evidence that indexation has returned in some large euro area countries. In Italy, for example, backward-looking indexation of wages now covers around one-third of private sector employees.[17]

Still, even if indexation rose, it would only create inertia in price formation: it would not obstruct the transmission process. As economic slack shrinks, upward pressure on prices will materialise and gradually enter the indexation ratchet.

So once again we see temporary forces at work that should not affect medium-term price stability. And this assessment is broadly what we see in market-based inflation expectations today. Interpreting with some caution, they are now consistent with the picture that our policy is effective, but that its full effects will take time to materialise.

17 Banca d’Italia (2017), box on “Private sector contract renewals in 2016”, *Economic Bulletin*, No 1, January.

5 Accompanying the recovery

So what do these various explanations imply for our monetary policy stance?

The first point to make is that we face a very different situation today from the one we encountered three years ago. Then, we also faced global shocks and significant labour market slack. But the recovery was still in its infancy. Global growth was slowing, depressing both import prices and net exports. Fiscal policy was less supportive than it is now. And headline inflation was much lower than today and inflation expectations more fragile, creating a higher risk of low inflation becoming entrenched.

In this context we faced another risk, too: of permanent damage to the economy through so-called “hysteresis effects”. Given the large degree of slack at the time, the risk was that if output remained below potential for too long, we would see a permanent destruction of productive capacity. The output gap would close the “wrong way” making the losses permanent.

When we said we wanted our policy to have effects without undue delay, we meant we wanted the output gap to close “upwards” – and before such hysteresis effects could develop. This is why we had to act forcefully.[18]

Now, we can be confident that our policy is working and that those risks have abated. The threat of deflation is gone and reflationary forces are at play. And since one of the drivers of inflation today is positive supply developments, this should feed back positively into potential output rather than produce hysteresis. In these conditions, we can be more assured about the return of inflation to our objective than we were a few years ago.

This more favourable balance of risks has been already reflected in our monetary policy stance, via the adjustments we have made to our forward guidance.

Another considerable change from three years ago is the clarification of the political outlook in the euro area. For years, the euro area has lived under a cloud of uncertainty about whether the necessary reforms would be implemented at both the domestic and Union levels. This acted as a brake on confidence and investment, which is tantamount to an implicit tightening of economic conditions. Today, things have changed. Political winds are becoming tailwinds. There is newfound confidence in the reform process, and newfound support for European cohesion, which could help unleash pent-up demand and investment.

Nevertheless, we are still in a situation of continuing slack, and where a long period of subpar inflation translates into a slower return of inflation to our objective. Inflation dynamics are not yet durable and self-sustaining. So our monetary policy needs to be persistent.

[18] For a fuller explanation of this point, see Draghi, M. (2016), “On the importance of policy alignment to fulfil our economic potential”, 5th Annual Tommaso Padoa-Schioppa Lecture at the Brussels Economic Forum 2016, Brussels, 9 June.

This is why the Governing Council has repeatedly emphasised that a very substantial degree of monetary accommodation is still needed for underlying inflation pressures to build up, and to support headline inflation in the medium term. This is reflected in our forward guidance on net asset purchases and interest rates, as well as our decision to reinvest the principal payments received under the APP for as long as necessary.

With reflationary dynamics slowly taking hold, we now need to ensure that overall financing conditions continue to support that reflationary process, until they are more durable and self-sustaining.

As the economy continues to recover, a constant policy stance will become more accommodative, and the central bank can accompany the recovery by adjusting the parameters of its policy instruments – not in order to tighten the policy stance, but to keep it broadly unchanged.

But there is an important caveat that we need to consider. Financing conditions are not only determined by the calibration of central bank instruments, but also by other market prices, some of which are significantly affected by global developments.

In the past, especially in times of global uncertainty, volatility in financial market prices has at times caused an unwarranted tightening of financial conditions, which has necessitated a monetary policy response.

So in the current context where global uncertainties remain elevated, there are strong grounds for prudence in the adjustment of monetary policy parameters, even when accompanying the recovery. Any adjustments to our stance have to be made gradually, and only when the improving dynamics that justify them appear sufficiently secure.

6 Conclusion

Let me conclude. Our assessment of the outlook for inflation and for monetary policy can be summed up in three messages.

The first is confidence that monetary policy is effective and the transmission process will work. All the signs now point to a strengthening and broadening recovery in the euro area. Deflationary forces have been replaced by reflationary ones.

While there are still factors that are weighing on the path of inflation, at present they are mainly temporary factors that typically the central bank can look through. However, a considerable degree of monetary accommodation is still needed for inflation dynamics to become durable and self-sustaining. So for us to be assured about the return of inflation to our objective, we need persistence in our monetary policy.

And, finally, we need prudence. As the economy picks up we will need to be gradual when adjusting our policy parameters, so as to ensure that our stimulus accompanies the recovery amid the lingering uncertainties.


INVESTMENT AND GROWTH
IN ADVANCED ECONOMIES
ECB FORUM
ON CENTRAL
BANKING
INVESTMENT

Robocalypse Now–Does Productivity Growth Threaten Employment?

By David Autor and Anna Salomons[19]

"Any worker who now performs his task by following specific instructions can, in principle, be replaced by a machine. This means that the role of humans as the most important factor of production is bound to diminish—in the same way that the role of horses in agricultural production was first diminished and then eliminated by the introduction of tractors." Wassily Leontief (1983)

Abstract

Is productivity growth inimical to employment? Canonical economic theory says no, but much recent economic theory says 'maybe'—that is, rapid advances in machine capabilities may curtail aggregate labor demand as technology increasingly encroaches on human job tasks, ultimately immiserating labor. We refer to this immiseration scenario as the "robocalypse," and explore empirically whether it is coming to pass by analyzing the relationship between productivity growth and employment using country- and industry-level data for 19 countries over 35+ years. Consistent with both the popular ('robocalypse') narrative and the canonical Baumol hypothesis, we find that industry-level employment robustly falls as industry productivity rises, implying that technically progressive sectors tend to shrink. Simultaneously, we show that country-level employment generally grows as aggregate productivity rises. Because sectoral productivity growth raises incomes, consumption, and hence aggregate employment, a plausible reconciliation of these results—confirmed by our analysis—is that the negative own-industry employment effect of rising productivity is more than offset by positive spillovers to the rest of the economy. Rapid productivity growth in primary and secondary industries has, however, generated a substantial reallocation of workers into tertiary services, which employs a disproportionate share of high-skill labor. In net, the sectoral bias of rising productivity has not diminished aggregate labor demand but has yielded skill-biased demand shifts.

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1 Introduction

One of the central stylized facts of modern macroeconomics, immortalized by Kaldor (1961), is that during a century of unprecedented technological advancement in transportation, production, and communication, labor's share of national income remained roughly constant (Jones and Romer, 2010). This empirical regularity, which Keynes (1939) deemed "a bit of a miracle," has provided economists—though not the lay public—with grounds for optimism that, despite seemingly limitless possibilities for labor-saving technological progress, automation need not ultimately make labor irrelevant as a factor of production. Indeed, mainstream macroeconomic literature often takes as given that labor's share of national income *is* constant and asks what economic dynamics enforce this constancy.[20]

But several recent developments have eroded economists' longstanding confidence in this constancy. One is a widely-shared view that recent and incipient breakthroughs in artificial intelligence and dexterous, adaptive robotics are profoundly shifting the terms of human vs. machine comparative advantage. Observing these advances, numerous scholars and popular writers anticipate the wholesale elimination of a vast set of currently labor-intensive and cognitively demanding tasks, leaving an ever-diminishing set of activities in which labor adds significant value (Brynjolfsson and McAfee, 2014; Ford, 2017; Frey and Osborne, 2017). We refer to this scenario—where the endless march of technology ultimately immiserates labor—as the 'robocalpyse.'[21]

While labor immiseration is a theoretical impossibility in canonical macroeconomic models of the economy, several recent papers develop models in which labor immiseration is one potential outcome. Sachs and Kotlikoff (2012) and Berg et al. (2017) develop overlapping-generation models in which rapid labor-saving technological advances generate short-run gains for skilled workers and capital owners, but in the longer run, immiserate those who are not able to invest in physical or human capital. Acemoglu and Restrepo (2016) consider a model where two countervailing economic forces determine the evolution of labor's share of income: the march of technological progress, which gradually replaces 'old' tasks, reduces labor's share of output, possibly diminishing real wages; and endogenous technological progress that generates novel labor-demanding tasks. The interplay of these forces can—but need not necessarily—yield a balanced growth path wherein the reduction in labor scarcity due to task replacement induces endogenous creation of new labor-using job tasks, thus restoring labor's share. Susskind (2017) develops a model in which labor is ultimately immiserated by the asymptotic encroachment of automation into the full spectrum of work tasks.[22] These models do not prove that

[20] Ngai and Pissarides (2007) and Acemoglu and Guerrieri (2012) formulate models in which ongoing unbalanced productivity growth across sectors (as per Baumol 1967) can nevertheless yield a balanced growth path for labor and capital shares.

[21] Short for the robotic apocalypse, of course.

[22] A critical distinction between Acemoglu and Restrepo (2017) and Susskind (2017) is that, in the latter model, falling labor scarcity does not spur the endogenous creation of new labor-using tasks or labor-complementing technologies, thus guaranteeing labor immiseration.

such immiseration will occur, but, contrary to canonical models, they sketch scenarios where it could.

A burgeoning empirical literature tests specifically whether technological progress has reduced aggregate labor demand or dampened overall wage growth. One robust finding in several recent papers is that labor's share of national income has fallen in many nations, perhaps commencing in the 1990s, and becoming plainly visible in the 2000s (e.g., Elsby, Hobijn and Sahin, 2013; Karabarbounis and Neiman, 2013; Piketty 2014; Dao et al. 2017). Reviewing an array of within- and cross-country evidence, Karabarbounis and Neiman (2014) argue that labor's falling share is due to a steep drop in the quality-adjusted equipment prices of Information and Communication Technologies (ICT) relative to labor. Though scholars have not reached consensus on this conclusion, Karabarbounis and Neiman's work has lent empirical weight to the conjecture that computerization is gradually rendering human labor redundant.[23]

If correct, this finding represents a substantial deviation from prior historical episodes. Alexopoulos and Cohen (2016) find that positive technology shocks raised productivity and lowered unemployment in the United State during the first half of the twentieth century. Focusing on contemporary European data, Gregory, Salomons, and Zierahn (2016) test whether Routine-Replacing Technical Change (RRTC) has reduced employment overall across Europe. They find that while RRTC has reduced middle-skill employment, this employment reduction is more than offset by compensatory product demand and local demand spillovers.[24] Looking directly at robotics, Graetz and Michaels (2015) estimate that industry-level adoption of industrial robots has raised labor productivity, increased value-added, augmented worker wages, had no measurable effect on overall labor hours, and modestly shifted employment in favor of high-skill workers within 17 EU countries. Conversely, using the same underlying industry-level robotics data but applying a cross-city design within the U.S., Acemoglu and Restrepo (2017) conclude that U.S. local labor markets that were relatively exposed to industrial robotics experienced differential falls in employment and wage levels between 1990 and 2007. One factor limiting the generalizability of this evidence is that robots are currently prevalent in only a small set of industrial applications, primarily in heavy industry. As robotics advances to encompass a broader set of non-industrial activities—e.g., healthcare, maintenance, cleaning, food preparation—the labor market consequences may also change.

[23] Although such a relative capital price decline should have no effect on factor shares if production technologies are Cobb-Douglas, there will be a decline in the labor share if the capital-labor elasticity of substitution is greater than one (a proposition for which Karabarbounis and Neiman find some evidence). Dao et al. (2017) present cross-country evidence from both developed and developing countries that machine-labor substitution, stemming from Routine-Replacing Technical Change (RRTC), contributes to a reduction in labor's share through falling middle-skilled labor demand. Analyzing data for both Europe and the U.S., Autor et al. (2017) conclude that the falling labor share is more likely accounted for by the rise of 'winner take most' competition rather than direct capital-labor or trade-labor substitution.

[24] Focusing not on employment but on sectoral and aggregate outputs, Nordhaus (2015) presents evidence that industrialized economies are *not* approaching an inflexion point at which technological advances generate a sharp and sustained acceleration of economic growth.

Recent public concern about the adverse employment effects of new workplace technologies has ample historical precedent. Over the last two centuries, scholars, political leaders, and social activists have issued periodic warnings that advancing automation threatened to make labor redundant and skills obsolete. The best-known early example is the Luddite movement of the early 19th century, in which a group of English textile artisans protested the automation of textile production by seeking to destroy some of the machines. But this worry is hardly antiquarian. In 1927, U.S. Secretary of Labor James J. Davis foresaw a "…lack of employment caused by revolutionary appliances" (*NY Times*, 1927). Concern over automation and joblessness during the 1950s and early 1960s prompted U.S. President Lyndon B. Johnson in 1964 to empanel a "Blue-Ribbon National Commission on Technology, Automation, and Economic Progress" to confront the productivity problem of that period—specifically, the problem that productivity was rising so fast it might outstrip demand for labor. The commission ultimately concluded that automation did not threaten employment, but it viewed the possibility of technological disruption as sufficiently severe that it recommended, as one newspaper (*The Herald Press*, 1966) reported, "a guaranteed minimum income for each family; using the government as the employer of last resort for the hard core jobless; two years of free education in either community or vocational colleges; a fully administered federal employment service, and individual Federal Reserve Bank sponsorship in area economic development free from the Fed's national headquarters."[25]

That these dire predictions have proved inaccurate in earlier generations does not guarantee that they will be incorrect going forward. Although scarce labor should not be left fallow in the equilibrium of a competitive economy, no economic law stipulates that the scarcity value of labor will always be sufficient to support a reasonable standard of living. Indeed, the real earnings of less-educated workers in Germany, the United States, and the United Kingdom have fallen sharply over the last two to three decades *despite* a steep reduction in the non-college share of the working age population (Autor and Wasserman, 2013; Dustmann et al., 2014; Blundell, 2016). These losses, which are typically attributed to skill-biased demand shifts (Autor, Katz, and Kearney, 2008), underscore that technological change can directly reduce demand for broad skill groups even if it does not diminish labor demand in aggregate.

Abstracting from specific models, the fundamental concern raised by this literature is that labor-saving technological progress may ultimately curtail employment. This paper explores that concern by testing for evidence of employment-reducing technological progress. Harnessing data from 19 countries over 37 years, we characterize how productivity growth—an omnibus measure of technological progress—affects employment across industries and countries and, specifically, whether rising productivity ultimately diminishes employment, numerically or as a share of working-age population. We focus on overall *productivity* growth rather than specific technological innovations because (a) heterogeneity in innovations defies consistent classification and comprehensive measurement, and (b), because

25 See Autor (2015), on which this paragraph draws, for further discussion.

productivity growth arguably provides an inclusive measure of technological progress (Solow, 1956). While our primary productivity measure is raw labor productivity, measured as output per worker, we document that using either value-added per worker or Total Factor Productivity in place of output per worker yields highly comparable conclusions.

Relative to existing literature, our paper is distinct—and we think useful—in several respects. First, we apply a comprehensive albeit reduced-form approach to measuring technological progress, studying the employment consequences of rising labor productivity per se rather than the impact of specific technological innovations, adoptions, or rollouts (as in Akerman, Kostol and Mogstad, 2014; Graetz and Michaels, 2015; Acemoglu and Restrepo, 2017). While our approach does not provide the crisp causal identification that we would ideally offer, it provides a panoply of robust, cross-national, cross-industry, and over-time findings that provide a rich descriptive picture and a cohesive story of productivity growth's nuanced relationship to employment growth.

Second, we explore a comprehensive set of outcomes—employment, output, value-added, skill input—that in combination substantiate the plausibility and soundness of our main findings. Third, we investigate both the direct and indirect employment effects of productivity growth by explicitly allowing for cross-sectoral productivity spillovers. These cross-sectoral spillovers prove to be of first-order importance for our results. Finally, alongside the impact of productivity growth on overall employment, we explore distributional consequences for the demand for high-, medium-, and low-skill labor. Notably, these distributional consequences appear substantially more consequential than the total employment effects.

Our analysis proceeds in four steps. We first explore whether country-level labor productivity growth is in net employment-augmenting or employment-diminishing in aggregate. We next drill down to industry-level data to test whether, holding aggregate national productivity growth constant, industries experiencing differential productivity growth see a net increase or reduction in employment. Part three of the analysis considers the simultaneous effect of industry-level productivity growth on own-industry versus aggregate employment growth. This extension allows us to assess whether productivity growth in each major sector generates spillovers to employment in other sectors. We can further ask whether these own-industry effects and cross-sectoral spillovers have changed with time—in particular, whether their net effects have declined in the 2000s. The final empirical section of the paper assesses the implications of sectoral productivity growth for labor demand by skill group. This is relevant because, even if productivity growth has no effect on the *level* of employment, it may nevertheless have non-neutral impacts on the relative demand for high-, middle-, and low-educated workers.

Over the 35+ years of data explored here, we find that productivity growth has been employment-augmenting rather than employment-reducing; that is, it has *not* threatened employment. This is true whether we measure employment as the number of employed workers or the ratio of employed workers to working-age population.[26] This strong finding emerges despite robust evidence that industries experiencing rising labor productivity exhibit falling employment (as per Baumol, 1967). The reason that industry-level productivity growth typically raises net employment is because productivity growth in each sector—particularly in services—generates employment growth spillovers elsewhere in the economy. These spillovers are sufficiently large that they more than offset employment losses in industries making rapid productivity gains. Individually, we estimate that both the employment-reducing and employment-increasing effects of productivity growth are economically sizable: however, their net effect makes for a rather modest positive impact of productivity growth on employment. These same results hold whether our productivity measure is output per worker, value-added per worker, or sectoral level productivity. Moreover, we confirm that these results hold not just for employment but for final consumption, meaning that productivity growth leads to a significant output response that appears to offset its direct employment-reducing effect. This highlights that final demand increases and inter-industry output linkages play an important role in countervailing the task-replacing effects of technological change.

Despite the relative neutrality of productivity growth for aggregate labor demand, we estimate that this same force has been non-neutral for labor demand across skill groups. Specifically, rapid productivity growth in primary and secondary industries (manufacturing in particular) has generated a substantial reallocation of workers into tertiary service activities, both in high skill-intensive services (e.g., health, education, finance) and in low skill-intensive services (e.g., food service, cleaning, hospitality). Because these sectors have a comparatively bimodal skill distribution of employment—with a disproportionate share of employment in either high- or low-education jobs—the expansion of services relative to other sectors has tended to favor high- and low-skill workers at the expense of middle-skill workers (consistent with the reasoning in Goos, Rademakers, Salomons, and Vandeweyer, 2015). Productivity growth has therefore contributed indirectly to the well-known phenomenon of employment polarization (see Goos, Manning, and Salomons, 2009 and 2014; Michaels, Natraj and Van Reenen, 2013), though we find that the sectoral skew has been far stronger in favor of high- than low-skill labor.

A central—and yet simultaneously, pedestrian—takeaway from our analysis is that productivity growth is *not* the primary driver of rising or falling employment. We estimate that net employment changes resulting directly or indirectly from productivity growth are quite modest, amounting to only a few percentage points of net employment over more than three decades. Instead, the primary driver of employment growth is estimated to be population growth; the number of workers rises roughly in lock-step with the overall growth of citizens in a country. This observation, which is almost self-evident but not tautological, suggests that the conventional narrative in which automation is the critical factor in either eroding or augmenting employment misses the mark. Our findings instead support a more prosaic neoclassical story in which both labor supply and final demand for goods and

[26] Because our focus is on 'jobs' rather than total labor payments, we do not explore wage-bills or hours as outcomes in this analysis. See Ngai and Pissarides (2008) for a model of how uneven productivity growth across sectors can rationalize the falling or non-monotone behavior evolution of aggregate market hours over the twentieth century.

services jointly determine the level of employment, and where the key driver of both forces is the population of consumer-workers.

Since our data, like all others, are drawn from the past, nothing in our findings demonstrates that the so-far benign relationship between productivity growth and employment won't soon take a more sinister turn: as the fine print of every investment prospectus notes, past performance is not an indicator of future outcomes. Moreover, our omnibus approach to measuring technological progress does not distinguish among different technological advances that may have different labor market consequences, e.g., the personal computer versus the shipping container. We also note that measured labor productivity growth may emanate from non-technological sources, such as advancing trade and offshoring possibilities. The labor market consequences of these distinct sources of productivity growth—arising from heterogeneous technological advances as well as shifts in trade, offshoring, and global production chains—clearly warrant in-depth study that extends beyond the high-level approach applied here.

Nevertheless, our broad-brush analysis underscores a key insight of much recent work on the labor market impacts of technological progress, which is that the primary societal challenge that these advances have posed so far is not falling aggregate labor demand but instead an increasingly skewed income distribution (Brynjolffson and McAfee, 2014; Autor, 2015). Concretely, although the raw count of jobs available in industrialized countries is roughly keeping pace with population growth, many of the new jobs generated by an increasingly automated economy do not offer a stable, sustainable standard of living, while simultaneously, many highly-paid occupations that are strongly complemented by advancing automation are out of reach to workers without a college education. This process by which technological progress (alongside other causes) skews the distribution of rewards increasingly towards educated elites has been abundantly visible across the industrialized world for close to four decades (Katz and Autor, 1999; Acemoglu and Autor, 2011). Our analysis suggests that the productivity-induced sectoral reallocations of labor contribute indirectly to this powerful underlying trend.

2 Data and measurement

Our analysis draws on the EU KLEMS, an industry level panel dataset covering OECD countries since 1970 (see O'Mahony and Timmer, 2009). We use the 2008 release of EU KLEMS, supplemented with data from EU KLEMS 2011 and 2007 releases to maximize our data coverage (1970-2007). We limit our analysis to 19 developed countries of the European Union, excluding Eastern Europe but including Australia, Japan, South Korea, and the United States. These countries and their years of data coverage years are listed in Table 1. The EU KLEMs database contains detailed data for 32 industries in both the market and non-market economy, summarized in Appendix Table 1. We focus on non-farm employment, and we omit the poorly measured Private household sector, and Public administration, Defense and Extraterritorial organizations, which are almost entirely non-market sectors.[27] The end year of our analysis is dictated by major revisions to the industry definitions in the EU KLEMS that were implemented in the 2016 release. These definitional changes inhibit us from extending our consistent 1970-2007 analysis through to the present, though we plan to do so in future work.

Table 1
EUKLEMS data coverage by country

ISO code	Country	Years
AUS	Australia	1970-2007
AUT	Austria	1970-2007
BEL	Belgium	1970-2007
DNK	Denmark	1970-2007
ESP	Spain	1970-2007
FIN	Finland	1970-2007
FRA	France	1970-2007
GER	Germany	1970-2007
GRC	Greece	1970-2007
IRL	Ireland	1970-2007
ITA	Italy	1970-2007
JPN	Japan	1973-2006
KOR	South Korea	1970-2007
LUX	Luxembourg	1970-2007
NLD	Netherlands	1970-2007
PRT	Portugal	1970-2006
SWE	Sweden	1970-2007
UK	United Kingdom	1970-2007
USA	United States	1970-2005

Notes: EU KLEMS database, 2008 release supplemented with information from 2007 and 2009 releases.

We operationalize the measurement of employment and productivity as follows. Our primary employment measure is the number of persons engaged in work, though we have also experimented with excluding the self-employed and obtain similar results. Because measurement of value-added outside of manufacturing is typically somewhat speculative, our primary labor productivity is real gross output per worker. However, we also present a set of models using value-added per worker and value-added based total factor productivity. These alternative measures yield qualitatively similar findings, although total factor productivity growth seems to have the most strongly positive effect on employment. Table 2 summarizes employment and productivity growth by country for each of the four decades of our sample. Appendix Table 2 reports the corresponding data at the industry level, averaging across all countries and the entire sample period.

[27] Although EU KLEMS classifies healthcare and education as non-market sectors, they are a substantial and growing part of GDP across the developed world and, in many countries (e.g., the U.S.), also encompass a large private sector component. We therefore choose to retain these sectors in our analysis.

To document the relationship between productivity growth and consumption growth we use the 2013 release of the World Input Output Database (WIOD). WIOD provides world input-output tables covering 40 countries, including the 27 countries of the European Union, as well as 13 other major economies, for the years 1995 through 2011 (see Timmer et al., 2015). To link country and industry-level employment and productivity outcomes to the WIOD, we employ the WIOD's harmonized Socio Economic Accounts Database (SEA, release July 2014). The SEA database is sourced from EU KLEMS and further processed for full compatibility with the WIOD.

Table 2

Average annualized growth in employment and productivity by country

	100 x Δ log employment				100 x Δ log labor productivity			
	1970-1980	1980-1990	1990-2000	2000-2007	1970-1980	1980-1990	1990-2000	2000-2007
AUS	1.44	1.88	1.64	2.42	1.00	1.18	3.28	0.84
AUT	1.37	0.55	1.02	0.99	2.21	2.29	2.17	2.01
BEL	0.19	0.32	0.69	1.02	1.40	1.73	2.54	1.38
DNK	0.62	0.69	0.64	0.82	1.30	1.62	2.36	1.97
ESP	1.06	1.70	2.44	3.65	2.08	1.29	0.94	1.33
FIN	1.19	1.03	-0.54	1.39	2.50	2.31	2.59	1.99
FRA	1.09	0.51	0.74	0.97	2.06	2.04	1.73	1.36
GER	0.49	1.13	0.68	0.33	2.22	0.67	2.29	1.52
GRC	2.65	1.44	1.13	1.76	2.41	-0.06	0.72	1.64
IRL	1.92	0.78	4.18	3.53	2.32	2.89	2.16	2.27
ITA	1.48	0.99	0.36	1.47	2.42	1.80	2.15	0.07
JPN	1.59	1.44	0.49	-0.07	1.72	2.68	0.52	0.94
KOR	6.30	4.79	2.12	2.06	4.11	5.14	3.82	3.27
LUX	1.56	2.03	3.51	3.46	2.54	4.43	2.36	2.05
NLD	0.59	1.50	2.26	1.04	2.73	-0.63	1.62	0.94
PRT	1.86	-0.63	1.17	0.40	3.37	3.54	2.61	0.85
SWE	0.93	0.66	-0.51	0.89	0.97	1.29	2.74	1.92
UK	0.26	0.52	0.41	0.92	0.98	1.33	3.48	2.34
USA	2.51	2.00	1.75	0.12	0.36	0.94	1.97	2.30
Average	**1.53**	**1.23**	**1.27**	**1.43**	**2.04**	**1.92**	**2.21**	**1.63**

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Labor productivity is calculated as gross output over the total number of persons engaged. Average is the unweighted mean across countries.

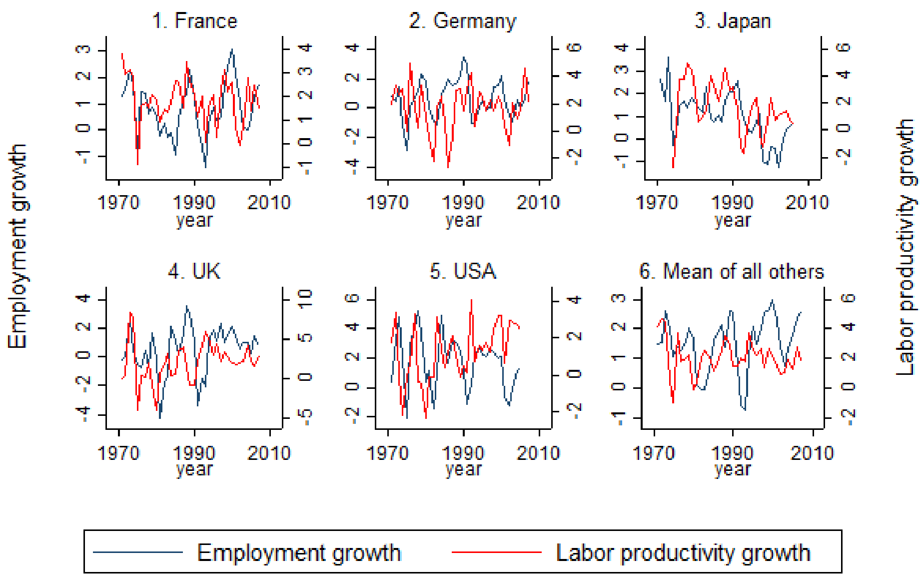
3 The big picture

Lay intuition would suggest that as countries become more productive, national incomes should rise, spurring additional consumption and concomitant employment growth. Figure 1 informally tests this intuition by plotting the evolution of productivity growth and employment growth in the five largest economies in our sample—France, Germany, Japan, the UK, and the US—as well as for the average of the remaining fourteen countries.[28] The productivity series is equal to the year-on-year log change in gross output per worker, while the employment series equals the year-on-year log change in the number of persons engaged in work, each multiplied by 100. Consistent with intuition, there is a striking time-series relationship between productivity growth and employment growth in all panels of the figure. From inspection, it appears that productivity growth typically leads employment growth by one to three years. However, the 2000s suggest a recent deviation from this pattern in which productivity and employment growth decouple: in the US and Japan, productivity rises rapidly in the 2000s while employment grows minimally; in the UK, conversely, productivity growth slows while employment grows relatively steadily. We return to the puzzle posed by this decoupling below.

Figure 1

Employment and productivity growth, 1970-2007: Large countries

(x-axis: year; y-axis: employment growth (left-hand scale), labor productivity growth (right-hand scale))



Figures are for the total economy, excluding agriculture, public administration, private households and extraterritorial organizations. All growth rates obtained as log changes x 100. Graph 6 reports unweighted mean growth rates across the remaining 14 countries. Productivity is gross output per worker.

To statistically characterize these time-series relationships, we estimate a set of stacked first difference OLS models of the form:

$$\Delta \ln E_{ct} = \beta_0 + \beta_1 \Delta \ln LP_{ct} + \left[\sum_{k=1}^{K} \beta_{2+k} \Delta \ln LP_{ct-k} + \alpha_c \right] + \varepsilon_{ct} \qquad [1]$$

28 Appendix Figure 1a shows similar results separately for 6 other countries; and Appendix Figures 1b and 1c highlight that the same patterns are found when alternatively using value added per worker as the productivity measure, or when using growth in employment to the total working age population.

where $\Delta \ln E_{ct}$ is the log change in employment in country c in time interval t, and $\Delta \ln LP_{ct}$ is the contemporary economy-wide growth in labor productivity. This model pools cross-country and over-time variation to estimate the conditional correlation between productivity and employment growth. Due to the log-log specification, estimates of β_1 correspond to elasticities. We perform these estimates without applying country weights, meaning that each country is given equal weight in the regression analysis. We can also augment the basic model by adding the terms in square brackets, representing, respectively, k time lags of labor productivity growth $\Delta \ln LP_{ct-k}$, and a set of country fixed effects α_c.[29]

Table 3a

The effect of productivity growth on employment growth at the country level.
Dependent variable: Annual log change in employment by country

	(1)	(2)	(3)	(4)	(5)	(6)
			A. OLS			
Δ ln productivity (c, t)	0.016 (0.032)	-0.046 (0.030)	-0.054 (0.035)	-0.080* (0.034)	-0.043 (0.033)	-0.064~ (0.033)
Δ ln productivity (c, t-1)	-	-	0.170** (0.035)	0.154** (0.033)	0.177** (0.032)	0.163** (0.032)
Δ ln productivity (c, t-2)	-	-	0.074* (0.035)	0.055~ (0.033)	0.059~ (0.032)	0.051 (0.032)
Δ ln productivity (c, t-3)	-	-	0.090** (0.033)	0.059~ (0.031)	0.063* (0.031)	0.050 (0.031)
Δ ln total population (c, t)	-	-	-	-	1.459** (0.144)	1.013** (0.187)
Country fixed effects	*NO*	*YES*	*NO*	*YES*	*NO*	*YES*
R2	0.000	0.203	0.071	0.244	0.201	0.278
N	696	696	639	639	639	639
Σk Δ ln productivity (c, t-k)	0.016 (0.032)	-0.046 (0.030)	0.280** (0.057)	0.190** (0.060)	0.256** (0.053)	0.199** (0.059)
			B. IV			
Δ ln productivity (c, t)	0.319** (0.101)	0.326** (0.091)	0.671** (0.238)	0.586** (0.179)	0.747** (0.236)	0.648** (0.182)
Δ ln productivity (c, t-1)	-	-	0.502** (0.179)	0.457** (0.147)	0.497** (0.178)	0.448** (0.147)
Δ ln productivity (c, t-2)	-	-	0.322~ (0.186)	0.282~ (0.153)	0.320~ (0.185)	0.275~ (0.153)
Δ ln productivity (c, t-3)	-	-	0.242 (0.168)	0.191 (0.135)	0.185 (0.169)	0.130 (0.135)
Δ ln total population (c, t)	-	-	-	-	1.471** (0.238)	1.441** (0.282)
Country fixed effects	*NO*	*YES*	*NO*	*YES*	*NO*	*YES*
N	696	696	639	639	639	639
Sanderson-Windmeijer F-stat	88.8	102.2	23.0	39.5	23.2	38.7
Σk Δ ln productivity (c, t-k)	0.319** (0.101)	0.326** (0.091)	1.737** (0.473)	1.516** (0.329)	1.748** (0.471)	1.501** (0.329)

Notes: All models estimate stacked annual differences over 1970-2007 for the total economy, excluding agriculture, public administration, private households, and extra-territorial organizations. The number of observations is equal to the number of countries multiplied by the number of years. Standard errors in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

[29] Our country-level estimates are unweighted so that larger countries do not have greater influence on the point estimates than smaller countries. When we turn to country-industry level estimates below, we weight industries by their relative sizes within countries, though again each country is given equal weight.

Table 3a presents a first set of results. Contrary to the impression given by Figure 1, the column 1 estimate in panel A finds a statistically insignificant and inconsistently signed conditional correlation between productivity growth and employment growth. The point estimate of 0.02 in column 1 implies that a 10 percent rise in labor productivity predicts a trivial one-fifth of a percentage point rise in employment. When country dummies are added to the model in column 2, so that identification comes from over-time, within-country variation, the point estimate becomes weakly negative, implying that rising productivity predicts falling national employment.

3.1 Building on the basics

Two limitations of the bare bones OLS setup are likely to bias the regressions towards finding a null or negative relationship between productivity growth and employment. First, Figure 1 suggests that there is a non-trivial lag structure between productivity growth and employment. These lags are absent from our initial OLS estimates. Second, because employment serves as *both* the dependent variable of the estimating equation *and* the denominator of the main explanatory variable (i.e., output divided by employment), measurement error in employment will tend to induce simultaneity between the dependent and (negative of) the independent variables, thus biasing OLS estimates downward. We address both issues in subsequent estimates in Table 3a.

Columns 3 and 4 of the upper panel of Table 3a augment our simple static setup with three lags of the productivity growth measure ($\Delta \ln LP_{ct-k}$).[30] Summing across the contemporaneous and lag coefficients, and focusing on the model containing country dummies (even-numbered columns), we obtain an employment-productivity elasticity of 0.19. This estimate implies that a ten percent rise in aggregate labor productivity in a given year predicts a two percent rise in aggregate employment over the ensuing four-year interval.

While these simple distributed lag models address the timing issue highlighted by Figure 1, they do not address the simultaneity bias problem noted above—specifically, that transitory fluctuations (or measurement errors) in the employment variable may generate simultaneity that biases the point estimate downward. Panel B of Table 3a attempts to tackle this issue by re-estimating each of the OLS models using an instrumental variables specification in which labor productivity growth in each country c is instrumented by the average of the contemporaneous labor productivity growth in all *other* countries c' in the sample. Appendix Table 3 reports the first stage estimates of these instrumental variables models, which are well identified across all columns and readily clear the Sanderson-Windmeijer (2016) F-test criterion for weak identification.

The IV estimates for the employment-productivity elasticity reported in panel B are in all cases larger (more positive) than their OLS counterparts. Distinct from the OLS

30 We considered one-, two-, and three-year lags. These lags are always positive and in most cases statistically significant. A fourth lag is never statistically significant.

models, both the lagged *contemporaneous* productivity growth measures strongly predict employment growth in IV specifications. In the first pair of columns, we obtain a contemporaneous productivity-employment elasticity of approximately 0.33. Adding three lags boosts this estimate to 1.52, which is nearly an order of magnitude larger than the corresponding OLS estimate.

It is worth considering which set of estimates—OLS or IV—should be viewed as more reliable. While the IV estimates purge the simultaneity bias stemming from measurement error that potentially biases OLS estimates downward, the other-country instruments do not resolve all threats to validity and may introduce threats of their own. An optimistic view of the instrument is as follows. The common cross-country component of labor productivity growth may plausibly reflect shared cross-national technological advances. If so, the predictive relationship between other-country and own-country productivity growth should capture the technologically driven component of rising productivity, purged of both measurement error and idiosyncratic own-country shocks. This will produce a strong first stage, which is precisely what we see.

The problem that this IV strategy potentially introduces is that these shared technology shocks may not pass the exclusion restriction. Suppose that when countries experience rising productivity, they apply some of their greater purchasing power to import goods from abroad, stimulating employment growth among trading partners. In this case, our instrumental variable approach will likely exaggerate the causal effect of own-country productivity growth on own-country employment because productivity growth will affect employment both through own-productivity gains and from simultaneous growth of export demand from trading partners. This source of bias, which is a macroeconomic doppelganger of the well-known ‘reflection problem’ in estimating peer effects, may help to explain why instrumental variables estimates are much larger than their OLS counterparts.[31] These observations suggest caution in placing great weight on the instrumental variables estimates, and cause us to favor the OLS models going forward.

3.2 Employment, population, and employment to population

Because we have so far taken total employment as our dependent variable, the estimates above do not directly answer the question of whether productivity fluctuations affect the employment *rate*—that is, the fraction of working age adults who are employed. If for example population growth and productivity growth covary positively at the country-by-time level, we might find that rising productivity predicts rising employment and, simultaneously, a fall in the employment-to-population ratio. To explore this possibility, the final two columns of Table 3a include the log of

[31] A further limitation of the IV approach is that, by using each country as an instrument for every other country, it is asymptotically equivalent to using the time series average of cross-country productivity growth as the instrument for each country simultaneously. To see this, observe that in a finite set of countries, our instrument differs from the time series of average cross-country productivity growth only because it omits own-country productivity growth from the time-series average. As the number of countries becomes large, this distinction becomes irrelevant.

country-by-year population as an additional regressor. Unsurprisingly, these estimates confirm that population is a strongly positive and highly significant predictor of employment; the number of workers rises with population. Less expected but equally consequential, the population control has almost no detectable effect on the estimated relationship between productivity and employment. The estimated productivity-employment elasticity is equal to 0.19 in the final OLS specification that excludes population (column 4), and is equal to 0.20 in the companion specification that includes population (column 6). Thus, omission of population from our macro-level regressions does not appear to bias the coefficients of interest.

Table 3b

The effect of productivity growth on employment growth at the country level. Dependent variable: Annual log change in employment to working age population by country

	A. OLS			
Δ ln productivity (c, t)	0.010 (0.029)	-0.026 (0.030)	-0.048 (0.033)	-0.056~ (0.033)
Δ ln productivity (c, t-1)	-	-	0.167** (0.033)	0.162** (0.032)
Δ ln productivity (c, t-2)	-	-	0.056~ (0.032)	0.050 (0.032)
Δ ln productivity (c, t-3)	-	-	0.059~ (0.031)	0.047 (0.031)
Country fixed effects	*NO*	*YES*	*NO*	*YES*
R2	0.000	0.082	0.064	0.138
N	696	696	639	639
Σk Δ ln productivity (c, t-k)	0.010 (0.029)	-0.026 (0.030)	0.235** (0.053)	0.203** (0.059)
	B. IV			
Δ ln productivity (c, t)	0.396** (0.098)	0.396** (0.093)	0.912** (0.276)	0.776** (0.200)
Δ ln productivity (c, t-1)	-	-	0.572** (0.208)	0.505** (0.164)
Δ ln productivity (c, t-2)	-	-	0.401~ (0.216)	0.339* (0.170)
Δ ln productivity (c, t-3)	-	-	0.294 (0.195)	0.218 (0.150)
Country fixed effects	*NO*	*YES*	*NO*	*YES*
N	696	696	639	639
Sanderson-Windmeijer F-stat	88.8	102.2	23.0	39.5
Σk Δ ln productivity (c, t-k)	0.396** (0.098)	0.396** (0.093)	2.179** (0.549)	1.839** (0.367)

Notes: All models estimate stacked annual differences over 1970-2007 for the total economy, excluding agriculture, public administration, private households, and extra-territorial organizations. The number of observations is equal to the number of countries multiplied by the number of years. Standard errors in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

A final noteworthy finding emerging from the final OLS specification in column 6 is that the coefficient on the log population variable is almost exactly equal to unity ($\hat{\beta} = 1.01, SE = 0.19$), suggesting that employment rises equiproportionately with population. If so, productivity growth should have roughly the same impact on the employment to population *rate* as it does on aggregate employment.[32] Table 3b confirms this hypothesis. When we replace the log population measure in equation (1) with the log of the employment-to-population ratio among working-age adults, we again find nearly identical point estimates for the employment-productivity elasticity. In the final (most complete) OLS specification in column 4 of Table 3b, this elasticity is estimated at 0.20, as compared to either 0.19 in the Table 3a specification that excludes population or to 0.20 in the Table 3a specification that includes population. The instrumental variables estimates are somewhat less stable than the OLS models, but the findings for employment to population in these models are qualitatively similar nonetheless to the earlier IV estimates for employment. We place limited weight on these models for the conceptual reasons noted above.

In estimates not tabulated here, we have confirmed that our results are highly comparable when using plausible alternative measures of employment: the number of hours worked in place of the number of workers; excluding self-employed workers; or treating part-time workers differently from full-time workers. We have additionally performed analogous estimates using as our measure of productivity value-added per worker, which differs from our primary output per worker measure by abstracting from fluctuations in the prices or quantities of energy, materials, or services used in production.[33] Our results are quite similar when using value-added, confirming a positive and statistically significant employment-productivity elasticity comparable to that reported above. In aggregate, rising labor productivity is unambiguously associated with growing employment and a rising employment to population ratio.

4 Breaking it down: Industry-level evidence

The country-by-time evidence above supports the longstanding presumption that productivity growth is not inimical to employment. But this analysis falls far short of addressing the concern that specific innovations may ultimately reduce net employment. Indeed, history provides numerous examples in which sectors with rapidly rising productivity have ultimately seen large falls in employment. Agriculture is the leading example of a sector that has shed employment as productivity has risen.[34] But agriculture is not an anomaly. Using more than a century of data on employment and productivity from textile, motor vehicle, and iron and steel production, Bessen (2017) shows that employment in each of these sectors followed an “inverted U” pattern: rising dramatically over multiple decades during an initial stage of innovation, then ultimately peaking and declining in later stages of maturity. Bessen interprets this pattern through a model of heterogeneous final demand, where demand becomes less elastic as the highest value needs are satisfied. Thus,

32 They could differ to the extent that growth of overall population and working-age population are not perfectly correlated.

33 A disadvantage of value-added as a productivity measure is that it is typically poorly measured outside of manufacturing.

34 Johnston (2001) documents that the U.S. agricultural, forestry, fishing and hunting employment was 11.8 million in 1900 and 1910 and then declined in each subsequent decade, reaching 3.4 million in 1990 (the last data point in Johnston’s series). The U.S. Bureau of Labor Statistics estimates that employment in these sectors was 2.1 million in 2014 (Hogan and Roberts, 2105).

in the initial stage of product or productivity innovation, price declines make formerly unavailable or prohibitively expensive goods affordable for mass consumption, yielding a large positive demand response. As high priority consumption demands are satisfied (e.g., clothing, cookware, and motor transportation become cheap and abundant), further labor- and cost-saving innovations yield only a modest further increase in demand. When this stage is reached, productivity advances depress sectoral employment.[35]

While our harmonized country-industry EU KLEMS data do not offer the historical sweep available to Bessen (2017), they provide considerable cross-industry, cross-country, and over-time variation with which to analyze the relationship between productivity and employment. We drill down on this relationship at the level of industries in this augmented estimating equation, where industries are indexed by i:

$$\Delta \ln E_{ict} = \beta_0 + \beta_1 \Delta \ln LP_{ict} \; [+ \delta_t + \; \alpha_c + \; \gamma_i] + \varepsilon_{ict}. \quad [2]$$

This equation captures the own-industry productivity-employment elasticity using variation across countries, over time, and across sectors within countries. The bracketed terms, which we add successively, purge several sources of potentially confounding variation: year effects take out common time trends affecting productivity and employment growth in all industries and countries simultaneously; country effects take out common trends affecting all industries within a country; and industry effects take out industry-specific trends that are common across countries.[36] We weight observations by the industry employment share in total country-level employment, averaged over the sample period. Thus, each country is given equal weight as above, while within each country, the weight given to each industry is proportional to its average share of own-country employment. Standard errors are clustered at the level of country-industry to avoid the Moulton (1986) aggregation problem. Panel A of Table 4 presents OLS estimates, while panel B presents IV estimates.

Table 4 depicts a clear inverse relationship between industry-level productivity growth and industry-level employment. Across all columns of panel A, we estimate a strong, stable negative employment-productivity elasticity. The point estimate of −0.25 for the employment-productivity elasticity in column 1 implies that a 10 percent rise in labor productivity yields a 2.5 percent fall in industry employment. This estimate is essentially unaffected by inclusion of time, country, industry effects or any combination thereof (columns 2 through 4). Consonant with the Table 3 estimates, we find that country-level population growth is a strong predictor of employment

[35] Matsuyama (2002) introduces a model where elasticities of demand change across a hierarchy of products as consumer incomes rise. As Bessen (2017) notes, however, Matsuyama's framework focuses attention on the *income* elasticity of demand whereas the sectoral-level evidence (i.e., from textiles, transportation, and iron and steel) suggests instead a first-order role for own-price elasticities (substitution effects) rather than income effects.

[36] Industry-by-country fixed effects are already implicitly taken out by first-differencing in the stacked first-difference model.

growth (in this case at the industry level) but has no detectable impact on the estimated employment-productivity elasticity.

Table 4

The effects of productivity growth on employment growth at the industry level.
Dependent variable: annual log change in employment by country-industry.

	A. OLS				
Δ ln productivity (cit)	-0.248** (0.024)	-0.259** (0.023)	-0.275** (0.024)	-0.249** (0.024)	-0.248** (0.024)
Δ ln population (ct)	-	-	-	-	0.895** (0.191)
Country fixed effects	*NO*	*YES*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*	*YES*
R2	0.110	0.155	0.201	0.300	0.305
N	19,451	19,451	19,451	19,451	19,451
	B. IV				
Δ ln productivity (cit)	-0.302** (0.042)	-0.305** (0.039)	-0.534** (0.041)	0.050 (0.109)	0.048 (0.108)
Δ ln population (ct)	-	-	-	-	1.036** (0.181)
Country fixed effects	*NO*	*YES*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*	*YES*
Sanderson-Windmeijer F-statistic	593.1	578.5	525.4	53.3	53.4
N	19,451	19,451	19,451	19,451	19,451
	First stage for Δ ln productivity				
Mean Δ ln productivity (it) in other countries	0.690** (0.028)	0.689** (0.029)	0.611** (0.027)	0.303** (0.042)	0.303** (0.042)

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is measured at the country-industry-year level. All models weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

In Appendix Table 4, we test whether these conclusions are altered when we allow for first and second-order lags of productivity growth, as was the case with the *aggregate* productivity growth estimates in Table 3. These industry-level productivity lags are in all cases small, generally insignificant, and do not affect the message of Table 4, which is that own-industry productivity growth dampens employment growth. (We omit industry-level productivity lags from subsequent tables for brevity.)

Might these estimates be biased downward by simultaneity stemming from correlated measure in the dependent and independent variables? Panel B of Table 4 explores this concern using an analogous strategy to that applied in Table 3: instrumenting own-country-industry productivity growth with contemporaneous own-industry productivity growth in other countries. Surprisingly, the IV point estimates are modestly *more negative* than the corresponding OLS estimates, suggesting that simultaneity bias is likely not a first order issue for the industry level regressions.[37]

We infer that during the time period under study, industries that experienced rapid productivity growth exhibited diminished employment growth. This result is in the spirit of the classic Baumol (1967) model, which posits that technologically advancing sectors—that is, those experiencing high productivity growth—will tend to contract relative to technologically lagging sectors.

5 Reconciling the micro elasticity with the macro elasticity

Given that aggregate productivity gains yield aggregate employment gains while sectoral productivity gains yield sectoral employment declines, we conjecture that the *indirect* positive effect of productivity growth on employment across sectors dominates the direct negative effect of own-sector productivity growth on own-sector employment. These indirect impacts may, in turn, accrue either through rising final demand (an income effect) or through interindustry demand linkages.

We explore evidence for this interpretation in Table 5 by pooling our macro (country-level) and micro (industry-level) approaches to estimate:

$$\Delta \ln E_{ict} = \beta_0 + \beta_1 \Delta \ln LP_{ict} + \sum_{k=0}^{3} \beta_{2+k} \Delta \ln \widetilde{LP}_{ct-k,j\neq i} \; [+ \delta_t + \; \alpha_c + \; \gamma_i] + \varepsilon_{ict}. \quad [3]$$

Here, $\Delta \ln LP_{ict}$ is the log change in own-industry labor productivity as per equation (2), and $\Delta \ln \widetilde{LP}_{ct,j\neq i}$ is the average log change in labor productivity in *other* industries in the same country and time period. In this estimating equation, the coefficient β_1 estimates the own-industry employment-productivity elasticity and the coefficient vector β_{2+k} estimates the indirect effect of productivity growth outside of own-industry i on industry $i's$ employment. Drawing upon our results above, we apply two simplifications to the empirical approach. First, because the Table 4 estimates suggest that simultaneity bias is not a first-order issue here, we omit the instrumental variables approach used in our country-level estimation. Second, we use both contemporaneous and k lags of aggregate productivity ($\Delta \ln \widetilde{LP}_{ct,j\neq i}$) to capture the dynamics revealed by the estimates in Table 3.

[37] That the IV estimate loses significance when industry effects are added (column 4 of panel B) reflects the limitation of the leave-out instrumental variable approach discussed in footnote 31. Almost all of the first stage identifying variation from this approach is cross- rather than within-industry, meaning that it is nearly collinear with industry dummies.

Table 5a

The effect of industry and aggregate productivity growth on employment growth. Dependent variable: annual log change in employment by country-industry

	(1)	(2)	(3)	(4)	(5)
Δ ln productivity (cit)	-0.279** (0.027)	-0.280** (0.027)	-0.283** (0.027)	-0.256** (0.026)	-0.255** (0.026)
Δ ln productivity (c, j≠i, t)	0.212** (0.064)	0.190** (0.062)	0.136* (0.065)	0.116~ (0.063)	0.127* (0.061)
Δ ln productivity (c, j≠i, t-1)	0.166** (0.042)	0.152** (0.035)	0.104** (0.034)	0.098** (0.034)	0.108** (0.032)
Δ ln productivity (c, j≠i, t-2)	0.097* (0.042)	0.080* (0.036)	0.061~ (0.036)	0.057 (0.036)	0.056 (0.034)
Δ ln productivity (c, j≠i, t-3)	0.097* (0.039)	0.069* (0.031)	0.067* (0.032)	0.063* (0.031)	0.059~ (0.031)
Δ ln total population (ct)	-	-	-	-	1.113** (0.191)
Country fixed effects	*NO*	*YES*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*	*YES*
R2	0.142	0.174	0.206	0.312	0.320
N	17,858	17,858	17,858	17,858	17,858
Σk Δ ln productivity (c, j≠i, t-k)	0.573** (0.091)	0.491** (0.086)	0.369** (0.091)	0.333** (0.090)	0.350** (0.088)
Σk Δ ln productivity (c, j≠i, t-k) + Δ ln productivity (cit)	0.294** (0.093)	0.211* (0.088)	0.086 (0.094)	0.078 (0.094)	0.095 (0.091)

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is measured at the country-industry-year level; aggregate productivity is the country-year level productivity with the own industry netted out. All models estimated with OLS and weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

Consistent with the reasoning above, we find that labor productivity growth has strongly countervailing effects on employment at the industry and at the aggregate level. In the first row of estimates, we find an employment-productivity elasticity in the range of −0.26 to −0.28, which is nearly identical to the estimates in Table 4. Thus, the addition of aggregate productivity measures to the estimating equation has no impact on the industry-level inference. Accounting for aggregate population growth also leaves the estimates unaffected (column 5).

Rows two through five of Table 5a report coefficients on contemporaneous and lagged aggregate productivity growth, $\Delta \ln \widetilde{LP}_{ct,j\neq i}$. In all specifications, aggregate productivity growth occurring *outside* of each sector has strong predictive power for employment growth within the sector. Summing over the contemporaneous coefficient and the three lags (second to last row), we estimate that each percentage point rise in external (other-sector) productivity predicts an own-sector employment rise of between 0.3 and 0.6 percent. The final row of the table sums over the own-sector and other-sector productivity coefficients to estimate the *net* effect of a percentage point rise in own- and other-sector productivity occurring simultaneously.[38] This net effect is in all cases positive but is not statistically

[38] While the aggregate and own-sector productivity will not typically move in tandem in each sector, these terms *must* maintain equality on average in each year since arithmetically, the mean of the leave-out means of other-sector productivity growth equals the grand mean of own-sector productivity growth.

significant when year and industry trends are included (columns 3 and 4). In the most demanding specification (column 5), which includes country-, industry-, and year-specific common effects, and the contemporaneous change in national population, we find an insignificantly positive *net* employment-productivity elasticity of 0.095. These estimates imply that the positive external effect of productivity growth on employment fully offsets the negative internal effect of industry productivity growth on own-industry employment.

5.1 Robustness: Employment rates, business cycles, and productivity measures

Because the results in Table 5a ultimately prove central to our primary conclusions, we have performed an extensive set of tests to probe their robustness. A first test is whether our findings for the impact of productivity growth on industry employment levels also apply to industry employment to population rates—that is the (log) ratio of industry employment to working-age population in a country year.[39] Table 5b confirms that this is the case. Estimates in Table 5b for the effect of productivity on employment-to-population rates find almost identical results to those for employment levels, as in Table 5a. This result is sensible in light of our finding above that the aggregate elasticity of employment with respect to population is virtually indistinguishable from unity, and confirms that our findings apply with equal force to employment levels and employment rates.

A second concern with our estimates is that they do not account for the cyclical nature of productivity growth. If for example, productivity growth is generally pro-cyclical as argued by Basu and Fernald (2001), we could erroneously conclude that rising productivity causes rising aggregate employment simply because both tend to rise and fall with the business cycle—and not because productivity growth is employment-enhancing. Appendix Tables 5a through 5c confront this challenge. Table 5a reports the OECD designated peak and trough business cycle years for each of the 19 countries in our sample. Appendix Tables 5b and 5c, respectively, re-estimate equation (3) for the employment-productivity elasticity using only peak-to-peak and trough-to-trough changes in employment and productivity. Thus, the number of observations for these models is equal to the total number of peaks or troughs (minus one) in each country multiplied by the number of industries.[40] Surprisingly, the peak-to-peak and trough-to-trough estimates of the employment-productivity elasticity, both at the own-industry and aggregate levels, are highly comparable to our main estimates above. We conclude that cyclicality does not pose an important confound for our main analytic approach.

A third, and potentially more fundamental, limitation of our estimates so far is that our primary labor productivity measure, output per worker, makes no distinction between

39 The denominator of the country-industry-year employment-to-population rate is the working age population for the country-year. By construction, the sum of country-year industry employment-to-population rates is equal to the country-year employment-to-population ratio.

40 All measures are annualized to account for the uneven length of peak-to-peak and trough-to-trough intervals across countries and over time.

output growth arising from changes in quantities or prices of inputs, from changes in value-added, and from changes in total factor productivity. Appendix Tables 5d and 5e address this limitation by re-estimating equation (3) using industry-level value-added per worker and industry-level total factor productivity (TFP), respectively, in place of output per worker. Using value-added per worker as the productivity measure, we obtain estimates that are almost indistinguishable from our primary results. Specifically, we estimate an own-industry employment-productivity elasticity of −0.24, a cross-industry spillover elasticity of +0.36, and a net productivity-employment elasticity of 0.11. As with the prior estimates using output per worker, the aggregate elasticity estimate is positive but not statistically significant.

Appendix Table 5e reports estimates that use TFP in place of labor productivity. These estimates present an even stronger case that productivity growth is *not* employment reducing. We obtain an employment-productivity elasticity estimate of −0.08 at the industry level, which is only one-third as negative as the elasticity estimated using output per worker or value-added per worker. This finding implies that industry-level pure productivity growth (i.e., the Solow residual) is *less* employment-reducing than simple increases in labor productivity (which may arise from various technological and non-technological sources). Complementing this finding, Table 5e reveals that the estimated employment spillover effect of TFP growth is *nearly identical* to that for the spillover effects of conventional labor productivity. In net, the effect of rising TFP on aggregate employment is strongly positive: we estimate a highly significant aggregate employment-productivity elasticity of +0.29, implying that each percentage point rise in TFP (occurring notionally across all industries simultaneously) predicts a 0.3 percentage point rise in national employment.

Why does TFP growth have a less negative effect on *own-industry* employment growth than does labor-productivity but a comparable (i.e., equally positive) spillover effect on employment? One reason may be that, unlike labor productivity (equal to gross output or value-added, denominated by employment), the TFP variable does not suffer from simultaneity arising from measurement error. This simultaneity will tend to drive the employment-productivity estimates into negative territory, as discussed in Section 3.1. This issue does not apply to TFP since TFP is explicitly purged of measured fluctuations in inputs, including labor. In addition, this concern does not apply to the relationship between either labor-productivity or TFP and other-sector (spillover) employment because measurement variation in own-industry employment should not be correlated with measurement variation in other-industry employment. Jointly, these observations may explain why TFP growth has a less negative predictive relationship to own-industry employment but an equally positive spillover effect to other-industry employment, comparable to labor productivity growth—and hence a stronger net effect on employment.

We emphasize, however, that estimated TFP gains are typically one-tenth to one-half as large as gains in conventionally measured labor productivity during this period, and are in many cases negative even though labor productivity growth is positive (see Appendix Table 2). Thus, the larger aggregate employment-productivity elasticity found for TFP as compared to labor productivity does *not* imply a qualitatively larger effect of productivity growth on overall employment growth.[41] We are not inclined to put highest weight on the TFP-based findings because TFP is, after all, merely a regression residual that is potentially subject to numerous measurement and specification artifacts. Nevertheless, we view these TFP results as strong evidence that our main models are unlikely to *overstate* the net employment-augmenting effect of rising productivity.

Table 5b

The effects of industry and aggregate productivity growth on employment growth. Dependent variable: annual log change in employment to working age population by country-industry

	(1)	(2)	(3)	(4)
Δ ln productivity (cit)	-0.278** (0.027)	-0.279** (0.027)	-0.283** (0.027)	-0.255** (0.026)
Δ ln productivity (c, j≠i, t)	0.219** (0.061)	0.214** (0.062)	0.144* (0.063)	0.123* (0.061)
Δ ln productivity (c, j≠i, t-1)	0.163** (0.035)	0.160** (0.032)	0.105** (0.032)	0.099** (0.031)
Δ ln productivity (c, j≠i, t-2)	0.079* (0.035)	0.074* (0.033)	0.052 (0.033)	0.048 (0.033)
Δ ln productivity (c, j≠i, t-3)	0.065* (0.031)	0.056* (0.028)	0.052~ (0.029)	0.047 (0.029)
Country fixed effects	*NO*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*
R2	0.144	0.155	0.190	0.300
N	17,858	17,858	17,858	17,858
Σk Δ ln productivity (c, j≠i, t-k)	0.526** (0.081)	0.505** (0.085)	0.352** (0.088)	0.317** (0.087)
Σk Δ ln productivity (c, j≠i, t-k) + Δ ln productivity (cit)	0.247** (0.083)	0.226* (0.086)	0.070 (0.091)	0.062 (0.091)

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is measured at the country-industry-year level; aggregate productivity is the country-year level productivity with the own industry netted out. All models estimated with OLS and weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

5.2 Does productivity growth raise consumption?

The robust finding that productivity growth is in net employment-augmenting implies that a combination of inter-industry output linkages and final demand effects fully offset the direct employment-reducing consequences of productivity growth. Thoroughly analyzing these linkages would require a cross-national input-output analysis as in Timmer et al. (2015), which is beyond the scope of this paper. As a small (tantalizing) step in this direction, we present evidence from consumption data that the conjectured linkage between productivity growth and consumption growth response is in fact evident. For this analysis, we draw on the World Input Output

[41] Put simply, these estimates do not alter the conclusion that the net effects of productivity growth on aggregate employment (netting over internal and spillover effects) are quite small.

Database (discussed in Section 2). We estimate a variant of equation (3) in which we regress the log of domestic consumption by country-industry-year on the log of country-industry-year gross output per worker.[42] Because of the limited time interval available from the WIOD (1995-2009), we exclude productivity lags from the analysis.

Table 6

The effects of industry and aggregate productivity growth on domestic consumption growth. Dependent variable: Annual log change in domestic consumption by country-industry

	(1)	(2)	(3)	(4)	(5)
Δ ln productivity (cit)	0.406** (0.053)	0.410** (0.053)	0.408** (0.054)	0.455** (0.057)	0.455** (0.057)
Δ ln productivity (c, j≠i, t)	0.043 (0.283)	0.119 (0.313)	0.098 (0.348)	0.070 (0.348)	0.070 (0.348)
Δ ln total population (ct)	-	-	-	-	0.874 (1.543)
Country fixed effects	*NO*	*YES*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*	*YES*
R2	0.024	0.042	0.243	0.255	0.256
N	6,838	6,838	6,838	6,838	6,838

Notes: Source: WIOT, 1995-2009. Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is measured at the country-industry-year level; aggregate productivity is the country-year level productivity with the own industry netted out. All models estimated with OLS and weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

Estimates of these models reported in Table 6 detect a highly robust own-industry consumption response to labor productivity growth. The estimates imply that each percentage point increase in productivity gives rise to almost a half percentage point rise in consumption. This robust pattern suggests that final demand is considerably below unit elasticity, consistent with the fact that industry employment falls as productivity rises. [43]

The second row of each model in Table 6 tests for spillovers from own-industry productivity growth to consumption of other-industry outputs. Unlike for employment, however, we do not detect significant spillovers. Although the spillover coefficient is uniformly positive, it is economically small in magnitude and never statistically significant. Given the limitations of this analysis—especially the fact that we do not incorporate input-output linkages—we take the Table 6 evidence as corroborating the presence of a productivity-consumption link but providing limited information on its economic magnitude.

[42] The consumption data come from the World Input Output tables. We use the sum of final consumption by households, non-profit organizations serving households, and by governments. Labor productivity, equal to gross output divided by employment, is from the Socio-Economic Accounts of the World Input Output Database. Population counts by country-year are from the World Bank.

[43] Appendix Table 6a shows that this conclusion is unaffected by using the value-added based productivity measure, and Appendix Table 6b highlights that results are qualitatively robust to removing 2008 and 2009 (the start of the Great Recession) from the data.

6 Not all productivity growth is equivalent: Heterogeneity in sectoral spillovers

As countries have industrialized during the 20th and 21st centuries, the locus of employment has shifted secularly from primary and secondary sectors—agriculture, mining, utilities, construction, and manufacturing—towards tertiary sectors supplying services to businesses and consumers (e.g., education, healthcare, transportation, wholesale and retail trade, business services, hotels and restaurants). This secular transformation is plotted in Figure 2a for the 19 countries in our sample.[44] In this figure and the analysis that follows, we combine our 28 industries into five exhaustive and mutually exclusive sectors: (1) mining, utilities and construction; (2) manufacturing; (3) education and health services; (4) capital-intensive ('high tech') services; and (5) labor-intensive ('low tech') services.[45]

Over the comparatively short timespan between 1970-2007, the share of employment in manufacturing dropped by more than 15 percentage points while the share in mining, construction, and utilities fell by roughly three percentage points. Conversely, the share of employment in education and health rose by eight percentage points, the share in high-tech services rose by ten percentage points, and the share in low-tech services rose by a modest two percentage points. The six panels of Figure 2b document that this secular transformation has occurred simultaneously (though not identically) within each of the five largest OECD economies—France, Germany, Japan, the UK, and the US—as well as in the average of the remaining fourteen smaller economies.[46]

[44] Paralleling our regression analyses, the figure reports an unweighted average of sectoral employment shares across nineteen countries. Consequently, the cross-national means are not primarily driven by the employment movements of larger countries.

[45] Specifically: Mining, utilities, and construction corresponds to industries C, E and F; Manufacturing is industries 15 through 37; Education and health services are industries M and N; High-tech services are industries 64, J, and 71 to 74; and Low-tech services are industries 50 to 52, H, 60 to 63, 70, and O. This particular high- and low-tech services division is obtained from the OECD.

[46] For reference, Appendix Figures 2a and 2b present the corresponding employment *shares* by sector (overall and by major country) rather than the share *changes* reported in Figures 2a and 2b.

Figure 2a

Cumulative changes in employment shares by sector for nineteen countries, 1970-2007 (1970 = 0)

(x-axis: year; y-axis: share change (percentage points))

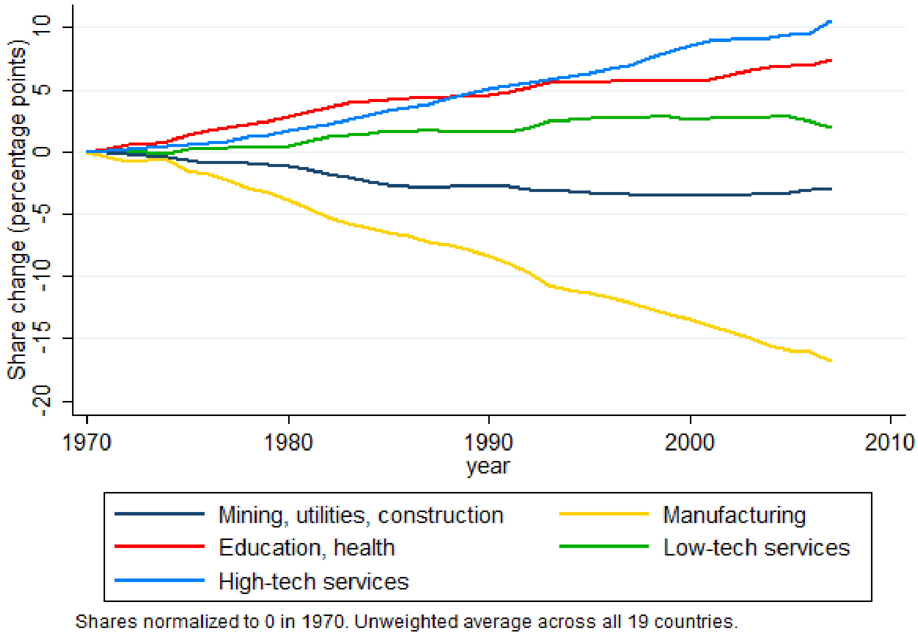
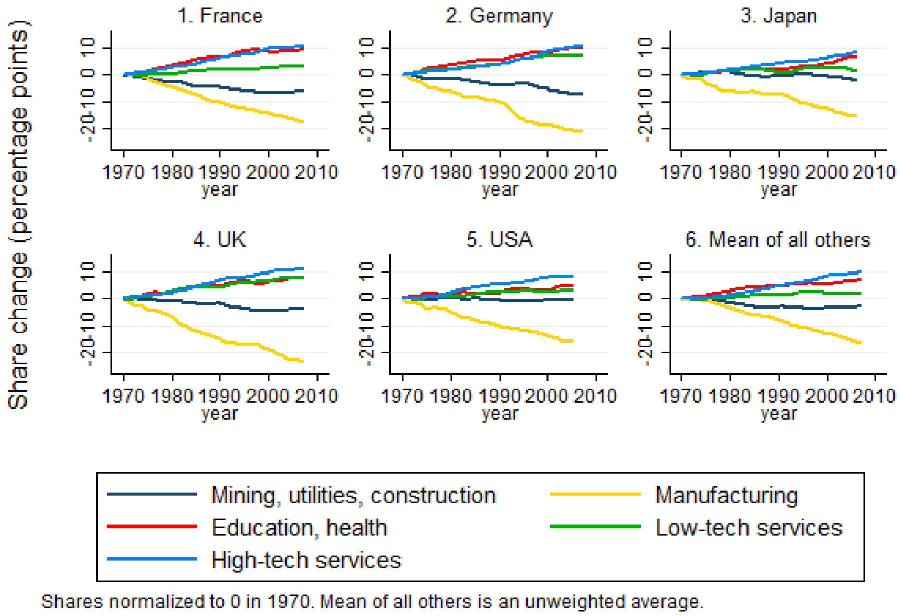


Figure 2b

Changes in employment shares by sector for the five largest economies in EUKLEMS, and for the average of the fourteen remaining economies, 1970-2007 (1970 = 0): Large countries

(x-axis: year; y-axis: share change (percentage points))

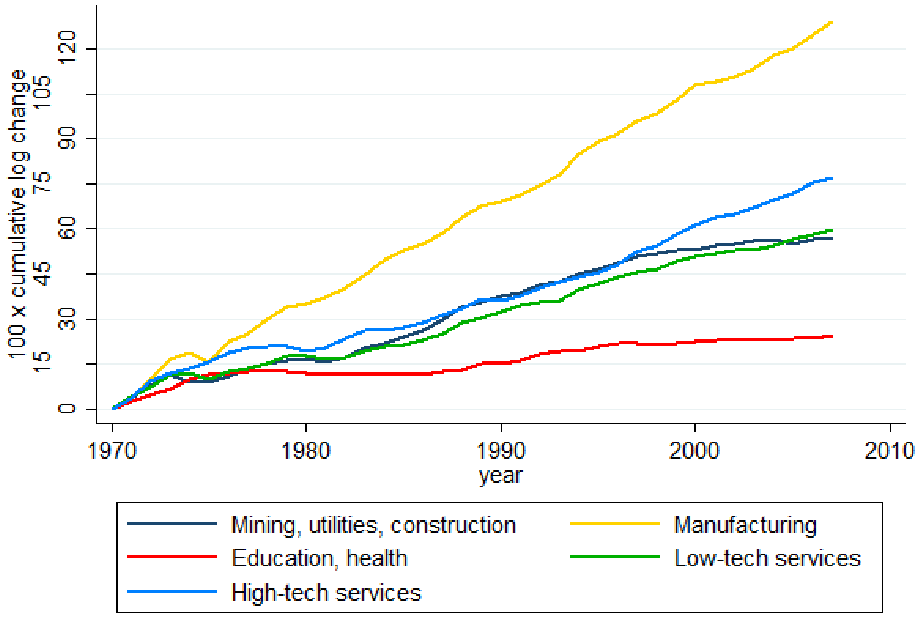


The substantial reallocation of employment across major sectors depicted in Figures 2a and 2b is inversely mirrored by trends in labor productivity growth across sectors. Figure 3a, which plots cumulative log labor productivity growth since 1970 by major sector, documents that productivity growth has been more than twice as rapid in manufacturing as in all other sectors while, conversely, productivity growth has been slowest—bordering on negligible—in education and health, and somewhat more rapid in high- and low-tech services, and in mining, utilities and construction.

Figure 3a

Cumulative log changes in labor productivity growth by sector for nineteen countries, 1970-2007 (1970 = 0)

(x-axis: year; y-axis: 100 x cumulative log change)



Unweighted average across all 19 countries. Productivity is gross output based.

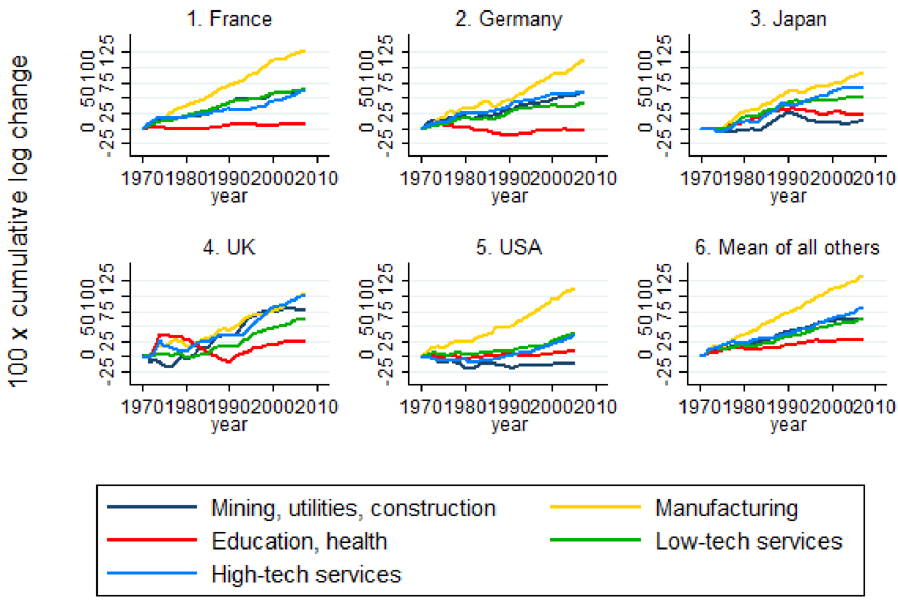
A qualitatively similar sectoral productivity pattern holds across all major countries, as documented in Figure 3b. In each of the five largest economies, manufacturing productivity growth has considerably outpaced that of all other major sectors. Education and health have experienced the lowest or second-lowest level of sectoral productivity growth in each of the big five economies, while productivity growth in high- and low-tech services has fallen somewhere in between these two extremes.[47] A comparison of the employment trends in Figure 2 with the productivity trends in Figure 3 highlights that, consistent with the Baumol (1967) hypothesis, sectors exhibiting more rapid productivity growth have contracted as a share of employment, while conversely those with slow productivity growth have expanded. The same conclusion emerges when using value-added rather than gross output per worker for our productivity measure, as reported in Appendix Figures 3a and 3b, respectively.

[47] Productivity growth in mining, utilities and construction has differed more substantially across countries.

Figure 3b

Cumulative log changes in labor productivity by sector for the five largest economies in EUKLEMS, and for the average of the fourteen remaining economies, 1970-2007 (1970 = 0): Large countries

(x-axis: year; y-axis: 100 x cumulative log change)



Mean of all others is an unweighted average. Productivity is gross output based.

The stark contrasts in employment and productivity growth across major sectors invite the question of whether our estimates above omit a critical interaction between productivity growth and employment growth. Implicitly, the models in Table 5 impose the restriction that the employment effect of productivity growth is symmetric across sectors: the employment-productivity elasticity is constrained to be identical across sectors; and, moreover, the external effects are similarly constrained, so that productivity growth in manufacturing must have the same external effect on employment in non-manufacturing as does productivity growth in non-manufacturing on employment in manufacturing.

These restrictions are unlikely to be realistic for several reasons. One is that the *external* effects of productivity gains in one sector on employment in others should depend, at least in part, on the economic heft of the sector experiencing the productivity gain. Concretely, a one percent productivity gain in services should have a larger impact on aggregate wealth—and hence likely aggregate employment—than a one percent productivity gain in agriculture simply because the service sector is so comparatively vast. Finally, these internal and external effects may change over time as incomes rise and as the demand for outputs of specific sectors saturates (as per Bessen, 2017), or as sectors become increasingly integrated in international production chains.

A second reason why these restrictions may not hold is that own-productivity elasticities may differ across sectors for the reasons suggested by Bessen (2017): in sectors where demand is relatively saturated (e.g., agriculture), final demand may respond only weakly to price-reducing or quality-increasing productivity increases; in sectors that are less mature (e.g., healthcare), productivity gains may be met with a strong demand response. Furthermore, one might expect that sectors with more competitive output markets experience a stronger price response as a result of productivity enhancements, resulting in a larger demand response and hence a less negative own-productivity elasticity. Another possible reason why own-productivity effects may differ across sectors is that the labor-replacing versus labor-complementing properties of technologies are sector-specific. And finally, the degree of international tradability of sectoral outputs could affect the extent to which any final demand response from productivity growth is in part met by foreign rather than domestic producers, thereby impacting the own-industry employment effect of productivity growth.

We explore sectoral heterogeneity in the employment-productivity relationship by relaxing the symmetry restrictions imposed by our Table 5 estimates. Specifically, we augment equation (3) to allow both own-industry and cross-sector employment-productivity elasticities to differ across the five broad sectors plotted above. Following the lag specification in Table 5, we include three lags of other-sector productivity growth alongside the contemporaneous measure. We do not include lags of own-industry productivity growth since as reported above, these lags are never significant. Our estimating equation is:

$$\Delta \ln E_{ict} = \beta_0 + \sum_{s(i)=1}^{5} \beta_{1,s(i)} \Delta \ln LP_{ict} + \sum_{s(i)=1}^{5} \sum_{k=0}^{3} \beta_{2+k,s(i)} \Delta \ln \widetilde{LP}_{ct-k,j \neq i} \; [+\delta_t + \alpha_c + \gamma_i] + \varepsilon_{ict}, \quad [4]$$

where we denote sectors with the subscript $s(i)$ to emphasize the correspondence between industry and sector. In this equation, $\widetilde{LP}_{ct-k,j\neq i}$ is sectoral productivity with the own-industry component netted out: since the 5 sectors are aggregates of our 28 industries, $\beta_{2+k,s(i)}$ captures the impacts of productivity growth in sector s(i), onto all industries, where for industries belonging to sector s(i), the own-industry productivity increase is netted out. Table 7 presents estimates.

We find considerable heterogeneity in both the own-industry (internal) and cross-sector (external) productivity effects on employment. Focusing first on the internal effects, we find that three of five sectors have internal employment-productivity elasticities in the range of −0.35, while both manufacturing and high-tech services have smaller elasticities (estimated at −0.15 and −0.23, respectively), implying that equivalent productivity gains displace proportionately fewer workers (as a share of industry employment) in these sectors.

Table 7

The effect of industry and aggregate sectoral productivity growth on employment growth. Dependent variable: Annual log change in employment by country-industry

	(1)	(2)	(3)	(4)	(5)
Mining & utilities & construction					
Δ ln productivity (cit)	-0.324** (0.042)	-0.318** (0.042)	-0.323** (0.042)	-0.319** (0.042)	-0.317** (0.042)
Σk Δ ln productivity (c, j≠i, t-k)	0.007 (0.036)	0.036 (0.034)	0.010 (0.033)	0.002 (0.034)	0.007 (0.033)
Manufacturing					
Δ ln productivity (cit)	-0.127** (0.023)	-0.130** (0.023)	-0.134** (0.023)	-0.149** (0.023)	-0.148** (0.023)
Σk Δ ln productivity (c, j≠i, t-k)	0.220** (0.048)	0.131** (0.049)	0.043 (0.049)	0.053 (0.048)	0.054 (0.044)
Education & health					
Δ ln productivity (cit)	-0.360** (0.039)	-0.360** (0.039)	-0.355** (0.040)	-0.359** (0.040)	-0.359** (0.040)
Σk Δ ln productivity (c, j≠i, t-k)	0.121** (0.043)	0.099* (0.039)	0.119** (0.036)	0.122** (0.036)	0.089* (0.037)
Low-tech services					
Δ ln productivity (cit)	-0.351** (0.047)	-0.350** (0.046)	-0.353** (0.046)	-0.348** (0.048)	-0.347** (0.047)
Σk Δ ln productivity (c, j≠i, t-k)	0.106 (0.068)	0.133* (0.065)	0.132* (0.062)	0.138* (0.062)	0.167** (0.060)
High-tech services					
Δ ln productivity (cit)	-0.263** (0.044)	-0.264** (0.042)	-0.263** (0.043)	-0.227** (0.041)	-0.229** (0.042)
Σk Δ ln productivity (c, j≠i, t-k)	0.128** (0.025)	0.137** (0.028)	0.120** (0.026)	0.093** (0.026)	0.071** (0.022)
Δ ln total population (ct)	-	-	-	-	0.972** (0.190)
Nr of lags in ln productivity (c, j≠i)	*k=3*	*k=3*	*k=3*	*k=3*	*k=3*
Country fixed effects	*NO*	*YES*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*	*YES*
R2	0.239	0.272	0.303	0.331	0.336
N	17,858	17,858	17,858	17,858	17,858

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is measured at the country-industry-year level; aggregate productivity is the sector-year level productivity with the own industry netted out. All models estimated with OLS and weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

More striking still is the heterogeneity in the estimated external effects of productivity. Productivity growth in mining, utilities, and construction has no measureable effect on employment growth in other industries. The external effect of productivity growth in manufacturing is also small in magnitude and statistically insignificant. Conversely, we estimate that productivity growth in high-tech services, and in health and education, raises other-industry employment with an elasticity of 0.07 to 0.09 (that is, a 10 percent productivity gain in these sectors raises economy-wide employment—excluding the source industry—by 0.7 to 0.9 percent). Finally, the external effects of productivity growth in low-tech services are roughly twice as large as any other sector, estimated at 0.17. This outsized spillover may stem from the fact that low-tech services is the largest sector in all major economies in our sample, typically encompassing 30 to 40 percent of employment (see Appendix Figure 2b), so that productivity gains in this sector may have a large positive effect on consumer purchasing power.

Summarizing, we find non-negligible sectoral heterogeneity in both the own- and cross-sector employment elasticities, indicating important roles for both Baumol effects—where productivity gains reduce own-sector employment—and positive demand linkages or income effects where rising sectoral productivity augments employment elsewhere in the economy. These findings are robust to alternatively using value added based productivity growth, as reported in Appendix Table 7a, or considering effects on the employment rate, shown in Appendix Table 7b.

To quantify what these statistical relationships imply for the net effect of productivity growth on employment, we consider the respective contributions to employment of productivity growth originating in each of these five broad sectors. These net effects will depend not only on the estimated own- and cross-sector elasticities, but also on the different productivity growth trajectories across industries and on their relative employment sizes. These relationships are formalized in equation (5):

$$\Delta\hat{E}_{ict} = \left\{E_{ic,t=base} \times 1(i \in s) \times \hat{\beta}_{1,s(i)} \times \Delta\ln LP_{ict}\right\} + \left\{E_{ic,t=base} \times \sum_{s(i)=1}^{5}\sum_{k=0}^{3}\hat{\beta}_{2+k,s(i)} \times \Delta\ln\widetilde{LP}_{ct-k,j\neq i}\right\} \quad [5]$$

In this equation, $\Delta\hat{E}_{ict}$ is the predicted employment change in industry i in country c and year t resulting from productivity growth occurring in i and in all other industries $j \neq i$. The first term in curly brackets represents the own-industry (internal) effect of labor productivity growth on employment, while the second term is the cross-industry (external or spillover) employment effect. The percentage annual employment change from the internal effect is given by the annual productivity growth in each industry multiplied by its sector-specific coefficient (denoted by the indicator function $1(i \in s)$ for the corresponding sector).[48] This annual percentage change is applied to base-year employment levels $E_{ic,t=base}$, where 1992, close to the midpoint of the sample period, serves as the base year.

Meanwhile, the percentage annual employment change resulting from the *external* productivity effect is given by the sum of productivity change in each sector *s* in the current and past three years–leaving out the industry's own productivity growth–multiplied by the respective sector-specific coefficients and their lags. This quantity is in turn multiplied by total country-level employment in the base year $E_{c,t=base}$, since these external effects operate on the entire economy. To obtain predicted employment changes by country and year, we sum each of these components across industries within countries for each time period. To abstract from differences in country size we scale predicted employment changes by countries' initial levels to obtain predicted percentage point changes. Equation (5) further allows us to study the separate contributions of the internal and external productivity effects to

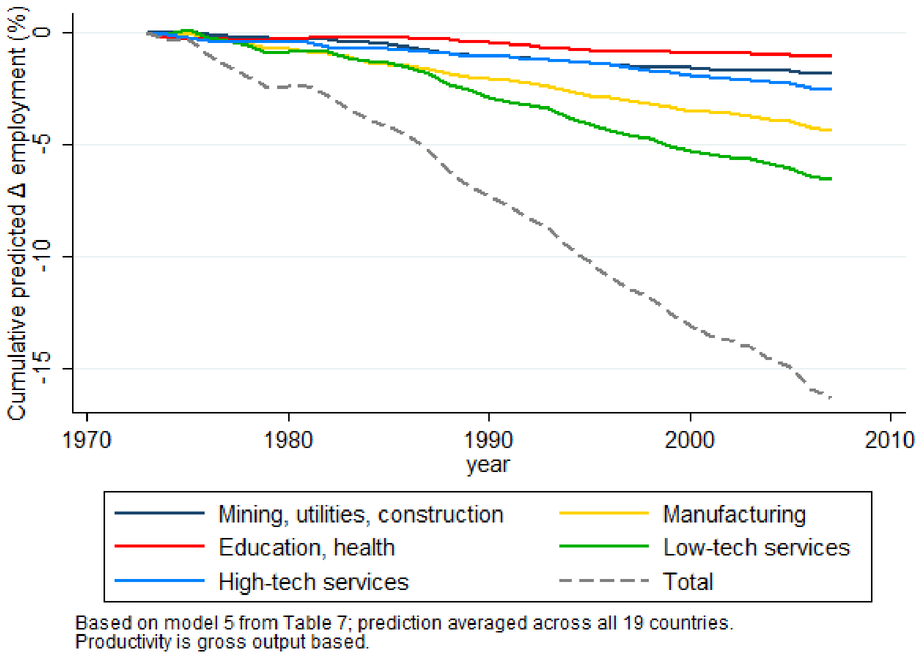
48 We exponentiate this term and subtract one to obtain percentage changes.

aggregate employment, as well as the separate contributions of productivity growth originating in any of the five broad sectors.

Figure 4a

Predicted cumulative percentage employment change from own-industry productivity growth originating in five sectors

(x-axis: year; y-axis: cumulative predicted Δ employment (%))



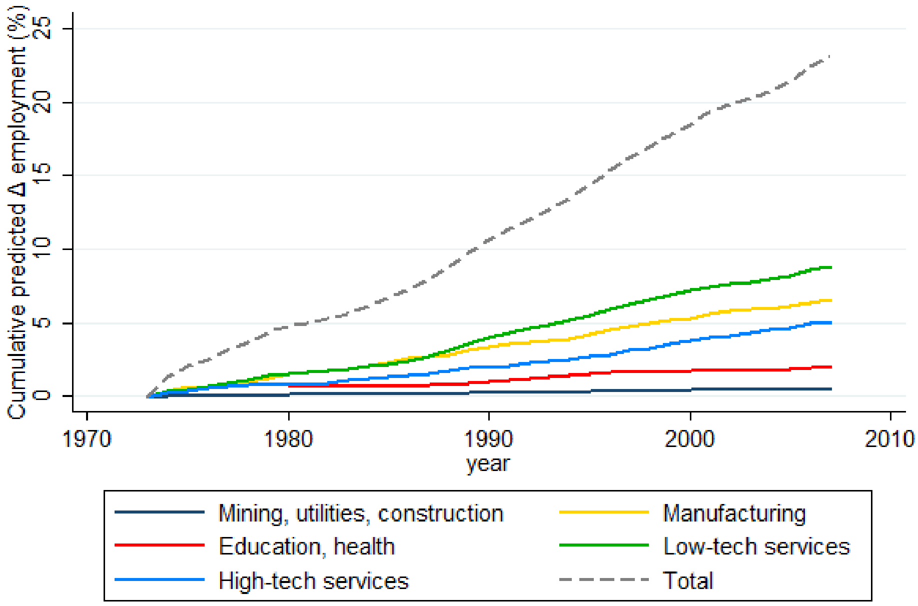
Starting with the internal effect, Figure 4a shows that the total effect of own-industry productivity growth (represented by the dashed gray line) is employment-reducing, amounting to a non-negligible decline in employment of more than 15 percent over the period. Although own-industry demand rises in response to a productivity increase (if not, the employment-productivity elasticity would equal negative one), this internal effect is insufficient to fully compensate the loss of employment from more efficient production. Of the total negative internal employment effect depicted by the gray dashed line, the largest contributions come from low-tech services and manufacturing. In the case of low-tech services, this is because it has one of the most negative own-industry employment elasticities, and a large share in total employment (see Appendix Figure 2a). Manufacturing, on the other hand, has a smaller negative own-industry employment elasticity but has witnessed outsized productivity growth, amplifying its contribution to the total effect. The smallest negative employment effect is due to productivity growth in education and health services. This is not because of an absence of Baumol effects or small sector size—indeed, this sector has the most negative own-industry employment elasticity and is among the largest in terms of employment size (see Appendix Figure 2a)—but because this sector has witnessed barely any productivity growth.

If these internal effects were the only channel through which productivity growth impacted labor demand, we would conclude technological progress *is* indeed inimical to employment. Yet our models show that there are spillovers accruing outside of the industry where the productivity growth originates. The contribution of these external effects to employment growth is plotted in Figure 4b. Here, we find that such effects have increased employment by over 20 percent over the period. Large positive contributions come from sectors that have a large heft in the economy (low-tech services) and those that have witnessed strong productivity growth (manufacturing, and to a lesser extent, high-tech services). On the other hand, productivity growth in mining, utilities, and construction has not produced an employment spillover at all, showing that the existence of these effects is not a given.

Figure 4b

Predicted cumulative percentage employment change from spillovers of productivity growth originating in five sectors

(x-axis: year; y-axis: cumulative predicted Δ employment (%))



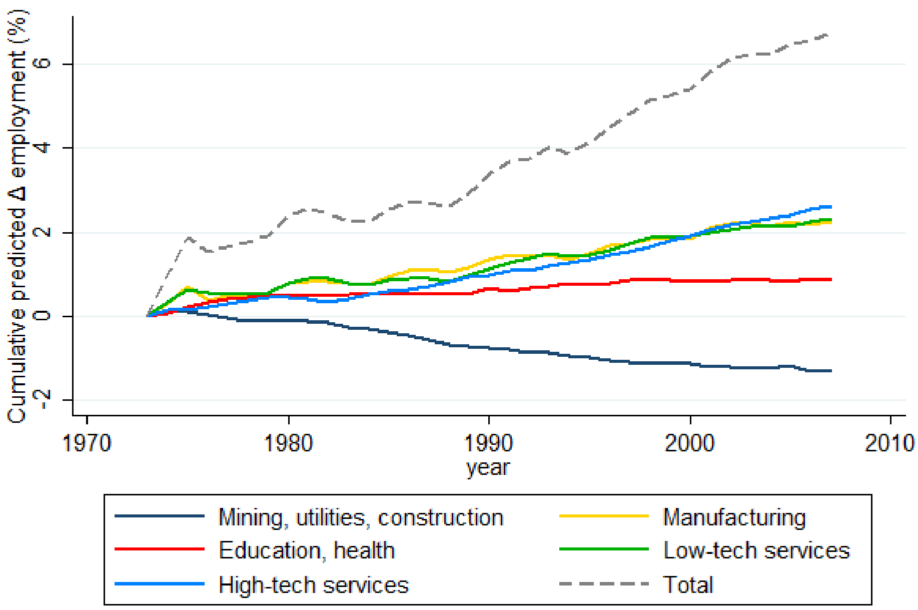
Based on model 5 from Table 7; prediction averaged across all 19 countries.
Productivity is gross output based.

Summing these internal and external components in Figure 4c, we find that the net effect of productivity on employment is *positive*, as indicated by the gray dashed line. The contributions of productivity growth from these five sectors, however, differ markedly, highlighting the importance of considering the source of productivity growth. We calculate that productivity growth in mining, utilities and construction has been *employment-reducing* in net over 1970-2007, stemming from the joint impacts of a negative internal effect of sectoral productivity on sectoral employment and a zero external effect of sectoral productivity growth on aggregate employment. On the other hand, productivity growth in manufacturing appears to have made a modest positive contribution to aggregate employment, reflecting its comparatively small (negative) own-industry employment elasticity and its small (positive) external productivity-employment elasticity. By implication, productivity growth in manufacturing appears to reduce manufacturing's share of employment while raising aggregate employment slightly. Productivity growth in the education and health sector makes a contribution similar to manufacturing to aggregate employment growth, reflecting slower productivity growth in this sector but larger external employment effects. Finally, the two subsectors of other services, high-tech and low-tech, make positive contributions, albeit for different reasons. Reflecting its relatively large external elasticity and large relative size, productivity growth in low-tech services makes the largest contribution to aggregate employment growth. Conversely, despite being smaller in size and having a lower external elasticity, productivity growth in high-tech services still makes a positive, albeit smaller, contribution to aggregate employment growth, in part because it has witnessed higher productivity growth than low-tech services and, in part, because its internal elasticity is relatively small.

Figure 4c

Predicted cumulative percentage employment change from productivity growth originating in five sectors, summing own-industry and spillover effects

(x-axis: year; y-axis: cumulative predicted Δ employment (%))



Based on model 5 from Table 7; prediction averaged across all 19 countries.
Productivity is gross output based.

Thus, we estimate that labor productivity growth has generated net employment growth over the sample period for the countries considered. We note, however, that these net effects are modest in absolute magnitude—on the order of a few percentage points per decade—implying that the bulk of employment growth across countries and over time stems from other factors. Our conclusions are unaltered by alternatively considering value added per worker as a measure of labor productivity, as reported in Appendix Figure 4.

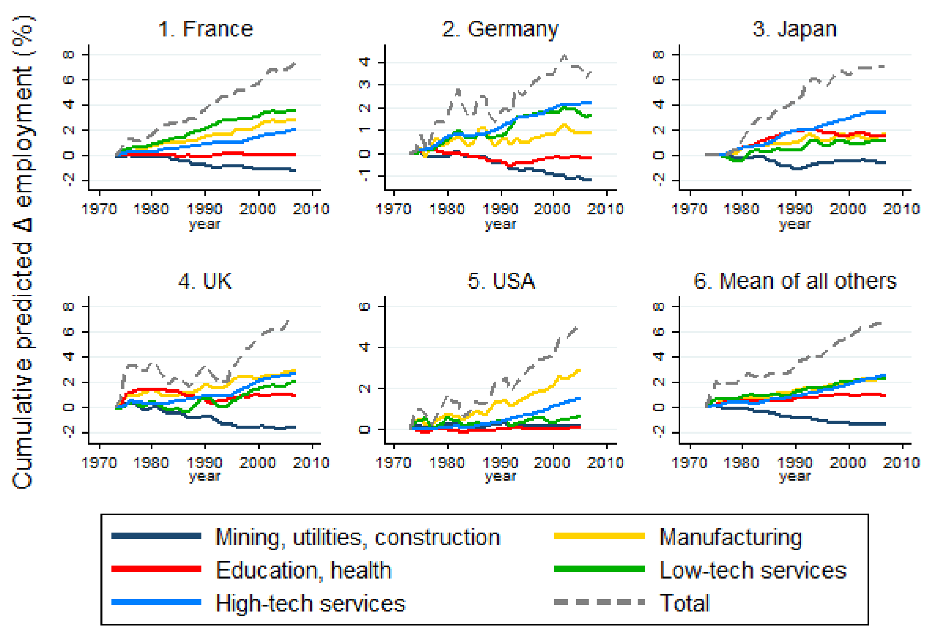
A central implication from the three panels of Figure 4 is that not all productivity growth is created equal. Despite the overall positive effect of economy-wide productivity growth uncovered by our country-level analyses, the sectoral sources of such productivity gains are non-neutral for their aggregate consequences. We should expect productivity growth to be less employment-augmenting in net if it is concentrated in sectors which do not produce a spillover onto employment growth elsewhere, such as mining, utilities, and construction. On the other hand, sectors with a relatively small spillover, such as manufacturing, can still produce a large positive external employment effect based on the sheer size of their productivity increase. In that sense, technological advances—say, assistive robots that raise productivity in health services, and other high- or low-tech services—may be a boon for employment growth since these sectors produce stronger spillovers.

Of course, these pooled cross-national estimates may not be representative of the experience of any one country. Although the estimated elasticities are constrained to be identical across countries—essentially assuming similar inter-industry or consumption linkages across each of these developed economies—this does not mean that the implied effects are homogeneous across countries. Because countries differ in both their sectoral productivity trajectories and cross-industry employment shares, productivity growth may make distinct contributions to aggregate employment in each country.

Figure 5

Predicted cumulative percentage employment change from productivity growth originating in five sectors, summing own-industry and spillover effects: Large countries

(x-axis: year; y-axis: cumulative predicted Δ employment (%))



Based on model 5 from Table 7. Productivity is gross output based.

We explore these differences in Figure 5 for the five largest economies in our sample, and for the average of the remaining fourteen. We estimate that labor productivity growth contributes positively in net to employment growth in all ‘big 5’ countries as well as across the other 14. Indeed, in all countries but the US, productivity growth in high- or low-tech services has had the strongest employment-increasing effects. For the US, however, productivity growth in services has been quite sluggish, rising a modest +25 percent over nearly forty years, as compared to something in excess of +50 percent for other major countries (see Figure 3b). In Japan, relatively strong productivity growth in high-tech services and health and education has contributed to aggregate employment growth. Similarly, in France, the UK, as well as other smaller countries, service economy productivity growth has been instrumental in driving a positive aggregate productivity-employment relationship. Appendix Figure 5 highlights that these conclusions are unaffected by using value-added as a base for calculating productivity.

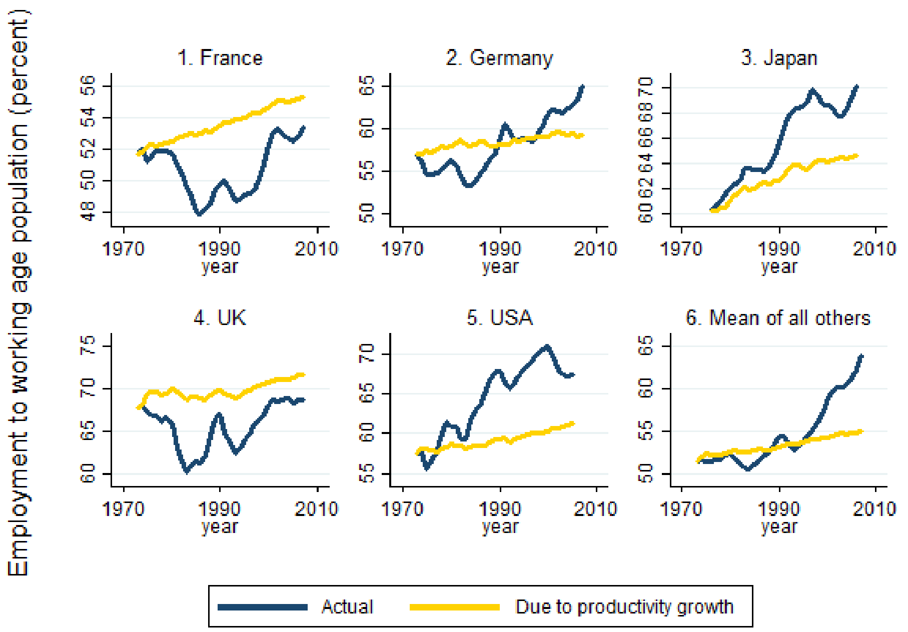
We further consider how sectoral productivity growth may have impacted employment to working age population ratios across economies by taking predictions from the companion set of models reported in Appendix Table 7b, where the dependent variable is employment-to-population (rather than employment as in Table 7). The implied contribution of productivity to the evolution of employment-to-population is plotted in Figure 6a for the five largest economies in our sample and the mean of all others, together with the actually observed employment rate evolution over this period. On average across these countries, our models imply that holding all else equal, productivity growth has raised the employment rate by some 3.6 percentage points, though this varies between 1 to 6 percentage points depending on the country.[49] These differences arise because of variation across countries in cumulative productivity growth and in the distribution of that growth (and of employment) across sectors. A key takeaway from these figures is that although productivity growth supplies an impetus for rising employment-to-population rates across most countries throughout this period, it is clearly not the predominant determinant of the differential evolution of employment rates across countries.

[49] As reported in Appendix Figure 6a, results are robust to instead using real value added per worker as a measure of productivity. Appendix Figure 6b shows predictions separately by country. The employment rate increase from productivity growth is predicted to be lowest in Greece and Spain, and highest in Denmark, Finland, Portugal, South Korea, and Sweden.

Figure 6a

Predicted cumulative percentage employment to working age population change from productivity growth originating in five sectors, summing own-industry and spillover effects: Large countries

(x-axis: year; y-axis: employment to working age population (percent))



Figures are for the total economy, excluding agriculture, public administration, private households and extraterritorial organizations. Productivity is gross output per worker.

Finally, we put the magnitude of the employment effects of productivity growth in perspective by considering their role relative to population growth. A consistent finding from our models above is that population growth and employment growth move close to equiproportionally, suggesting a large role for changes in population in determining employment. Figure 6c compares the contribution of these two forces, productivity growth and population growth, to the overall employment growth across the 'big 5' economies and all other countries.[50] Not surprisingly, the contribution of productivity growth to employment growth is minute relative to the contribution of population growth (see also Appendix Figure 6c, which reports this for each of the 19 countries separately, and Appendix Figure 6d, which presents highly comparable findings using value-added based labor productivity growth rather than output-based labor productivity growth). The realized employment trajectories of these countries (in navy) are typically closely matched by the predicted trajectory coming from population growth alone (in red), with productivity growth (in gold) contributing much less. The extent of this contribution does vary somewhat across countries: in Germany, Japan and the UK, productivity growth has a larger impact than in France and the US. Furthermore, some countries' employment performance has been worse

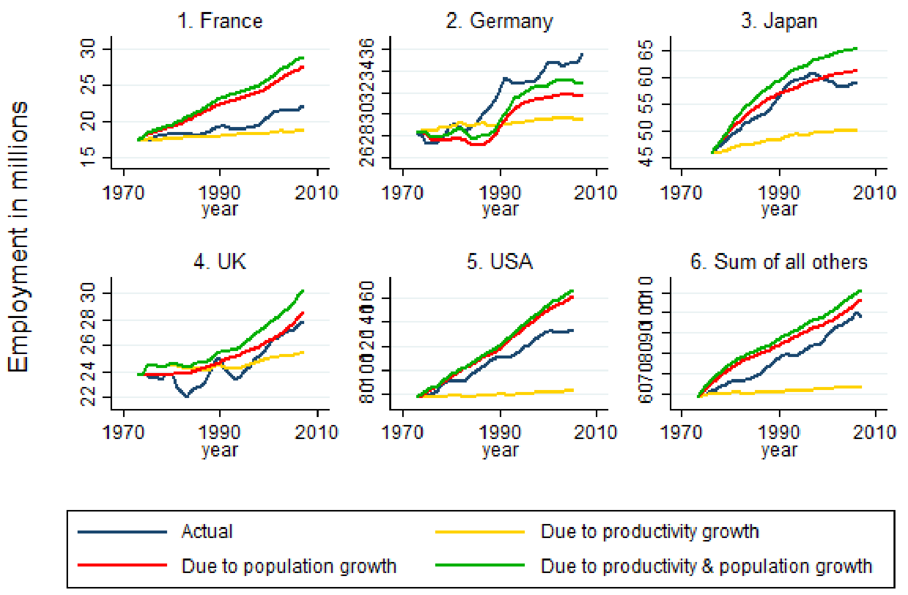
[50] The predictions for population growth are obtained in an analogous manner to those for productivity growth (as shown in equation 5), by multiplying the product of percentage changes in population and the exponentiated coefficient from model 5 of Table 7 (which also controls for productivity growth) with countries' base year population.

than is suggested by the combined forces of population growth and employment growth (shown as the green line)—this is the case in France, and to a lesser extent also the US and in more recent years, the UK. Germany, on the other hand, has performed better than its productivity and population growth would suggest. This implies these countries face other headwinds, or tailwinds as the case may be, from forces impacting employment growth (e.g labor supply, population aging, or international trade).

Figure 6b

Comparing the estimated effects of productivity growth and population growth to the evolution of employment by country, 1970-2007: Large countries

(x-axis: year; y-axis: employment in millions)



Figures are for the total economy, excluding agriculture, public administration, private households and extraterritorial organizations. Productivity is gross output based.

Of course, the 'result' that population growth is a central determinant of employment growth borders on self-evident—akin to the observation that large countries have more jobs. We nevertheless report this result to highlight that while productivity growth is central to rising living standards, it is not a primary driver of employment growth.

7 Is this time (period) different?

A noteworthy pattern evidenced by Figure 1 is that employment growth in several countries—the US, Japan, and the UK—appears to decouple from productivity growth during the 2000s. Thus, productivity growth appears less positive for employment growth, and productivity stagnation appears less adverse for employment growth, in this decade than in earlier periods. This pattern could suggest that the virtuous relationship between productivity growth and employment growth has begun to break down. This might occur, for example, if demand for any one industry's output becomes saturated as its most productive uses are exhausted (Bessen, 2017). Secondly, as the relative weight of sectors in the economy changes, so do the relative contributions on their internal versus external employment-productivity elasticities. Finally, changes in production technologies or the rising integration of production chains across countries may alter the nature of productivity-employment linkages. To explore these possibilities, we modify equation (3) to allow for decade-specific effects of both own-industry and net aggregate productivity:

$$\Delta \ln E_{ict} = \beta_0 + \sum_d \beta_{1,d(t)} \Delta \ln LP_{ict} + \sum_d \sum_k \beta_{2,d(t),k} \Delta \ln \widetilde{LP}_{ct-k,j\neq i} \ [+ \delta_t + \alpha_c + \gamma_i] + \varepsilon_{ict}, \tag{6}$$

where we use subscript $d(t)$ for decades (1970s, 1980s, 1990s, 2000s) to emphasize the correspondence between decade and year. Estimates of this model, where year, country, and industry fixed effects are cumulatively added across columns, are reported in the top panel of Table 8.

As a final refinement of our model, we also include a full set of decade interactions in equation (4):

$$\Delta \ln E_{ict} = \beta_0 + \sum_d \sum_s \beta_{1,s(i),d(t)} \Delta \ln LP_{ict} + \sum_d \sum_s \sum_k \beta_{2,s(i),d(t),k} \Delta \ln \widetilde{LP}_{ct-k,j\neq i} + \delta_t + \alpha_c + \gamma_i + \varepsilon_{ict}, \tag{7}$$

This specification, our most flexible one, allows both own-productivity (e.g. from demand saturation) and cross-productivity (e.g. from changing sector shares) effects to differ across sectors over time. Estimates of this model, with a full set of year, country, and industry fixed effects, are reported in Table 8.

Starting with the top panel of Table 8 with the specification where elasticities are common across sectors but differ across decades (equation 6), two main results emerge. First, own-industry productivity effects have become more negative over time: this is most pronounced when comparing the 1970s with any of the other three decades. This is consistent with saturation effects, though alternative interpretations are possible, such as a shift in the nature of technological progress (to become more labor-replacing), or an increase in trade openness which has led part of the increased domestic demand following productivity growth to be met by foreign producers. Regardless of the underlying cause, this result suggests that over-time changes in the own-sector price elasticity may play an important role in the evolving employment effects of labor productivity growth. Over (even) the relatively short data span considered here, we find that own-sector price elasticities have risen, suggesting it could be misleading to assume a stable employment-productivity relationship.

Secondly, the estimates indicate that the external effect of productivity growth on employment has varied considerably over time. It was seemingly strongest in the

1970s and 1990s, and weakest in the 2000s. Taking both internal and external effects together, the 2000s stand out as the decade when the virtuous relationship between productivity growth and employment growth was weakest. Indeed, our estimates suggest that the relationship was weakly negative (though this estimate is not statistically significant). This contrasts with the preceding decade, when the relationship was positive (though also statistically insignificant). These results therefore again serve to qualify our finding of an overall positive relationship between productivity growth and employment growth that prevailed *on average* across the four decades of our sample.

The bottom panel of Table 8 investigates to what extent these decadal changes in the employment-productivity relationship are driven by different effects emanating from the five broad sectors, by estimating of equation (7), where the internal and external effects of productivity growth are allowed to vary both by broad sectoral group and by decade. These estimates show that across sectors, the own employment-productivity elasticity has become more pronounced over successive decades. This is most pronounced in manufacturing, where the own-industry employment-productivity elasticity fell from close to zero to −0.29. Furthermore, manufacturing has experienced a decline in its external effect over time: this used to be positive in the 1970s but turned slightly negative since. The external effects for mining, utilities, and construction have remained constant at around zero over time, whereas the spillovers from services and health and education do not show a particular pattern over time and are positive and significant in most cases.

Taken together, the evidence reported in this section indicates that the virtuous productivity-employment relationship looks weaker in the 2000s than in prior decades. Specifically, the net productivity-employment effect is least positive in the most recent decade. This finding is reinforced by robustness checks reported in Appendix Tables 8a and 8b, which respectively use value-added based productivity measures, and consider the effect of productivity growth on employment rates rather than employment levels.

Figure 7 reports predictions separately by decade based on applying equation (7) to the estimates reported in Table 8. In all four decades of the sample, the internal effect of productivity growth on employment is significantly *negative* while in three of four decades—all but the 2000s—the external effect is significantly *positive*. Putting these pieces together, the net effect of productivity growth on employment growth has indeed fluctuated over time. It was strongly and significantly positive in the 1970s, small and statistically insignificant in the 1980s and 1990s, and—surprisingly—significantly negative in the 2000s, reflecting the absence of positive external employment effects in this decade.

Appendix Figure 7 shows corresponding results for value-added based productivity growth. As for gross output based productivity growth, we find a statistically significant positive net effect for the 1970s, insignificant net effects for the 1980s and 1990s, and statistically significant negative net effect for the 2000s. Unlike for gross output, however, the estimated net employment effects for value-added based productivity are monotonically decreasing across time periods.

Table 8

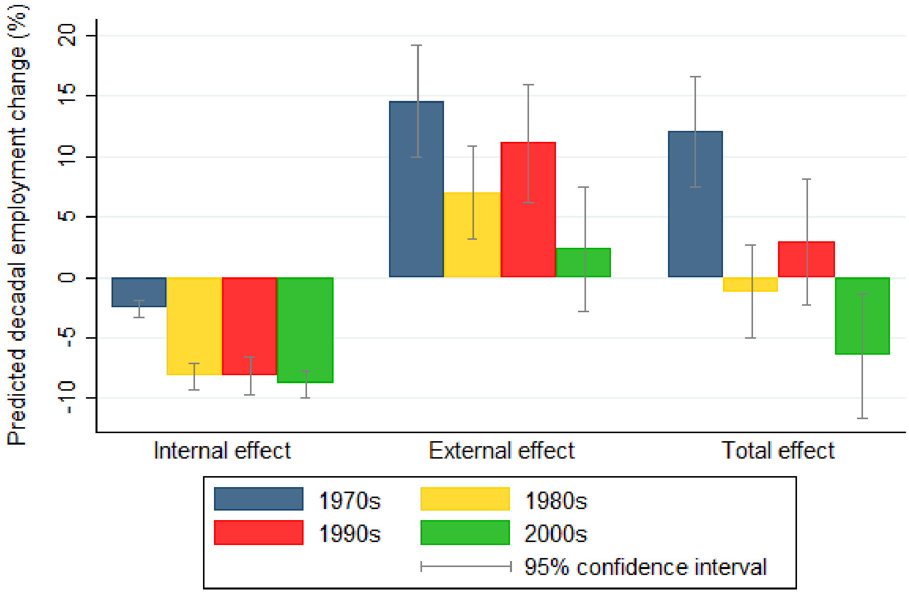
The decadal effects of industry and aggregate sectoral productivity growth on employment growth. Dependent variable: Annual log change in employment by country-industry

	1970s	1980s	1990s	2000s
All sectors				
Δ ln productivity (cit)	-0.151** (0.047)	-0.322** (0.052)	-0.255** (0.039)	-0.301** (0.034)
Σk Δ ln productivity (c, j≠i, t-k)	0.567** (0.136)	0.211 (0.147)	0.424** (0.121)	0.092 (0.142)
Σk Δ ln productivity (c, j≠i, t-k) + Δ ln productivity (ict)	0.416** (0.124)	-0.112 (0.161)	0.168 (0.116)	-0.210 (0.142)
Mining & utilities & construction				
Δ ln productivity (ict)	-0.185** (0.057)	-0.351** (0.062)	-0.457** (0.093)	-0.297** (0.054)
Σk Δ ln productivity (c, j≠i, t-k)	-0.027 (0.050)	0.066 (0.054)	-0.061 (0.084)	0.057 (0.041)
Manufacturing				
Δ ln productivity (cit)	-0.037 (0.039)	-0.138** (0.031)	-0.156** (0.033)	-0.292** (0.056)
Σk Δ ln productivity (c, j≠i, t-k)	0.235** (0.074)	0.024 (0.089)	-0.047 (0.092)	-0.056 (0.075)
Education & health				
Δ ln productivity (cit)	-0.257** (0.082)	-0.399** (0.060)	-0.303** (0.072)	-0.482** (0.079)
Σk Δ ln productivity (c, j≠i, t-k)	0.097* (0.039)	-0.010 (0.068)	0.261~ (0.142)	0.241** (0.087)
Low-tech services				
Δ ln productivity (cit)	-0.270** (0.074)	-0.495** (0.072)	-0.284** (0.075)	-0.268** (0.030)
Σk Δ ln productivity (c, j≠i, t-k)	0.232** (0.079)	0.129 (0.110)	0.235* (0.104)	0.019 (0.072)
High-tech services				
Δ ln productivity (cit)	-0.146* (0.062)	-0.270** (0.091)	-0.236** (0.047)	-0.278** (0.031)
Σk Δ ln productivity (c, j≠i, t-k)	0.053~ (0.032)	0.071* (0.035)	0.184** (0.052)	0.082 (0.051)
Δ ln total population (ct)	0.900** (0.160)			
Nr of lags in ln productivity (c, j≠i)	k=3			
Country fixed effects	YES			
Year fixed effects	YES			
Industry fixed effects	YES			
R2	0.365			
N	17,858			

Figure 7

Predicted cumulative percentage employment change by decade from productivity growth originating in five sectors

(y-axis: predicted decadal employment change (%))



Based on sector-specific model from Table 8. Predictions for the 1970s and 2000s scaled up to be comparable to the 1980s and 1990s. Confidence interval constructed by bootstrapping predictions (1,000 repetitions). Productivity is gross output per worker.

We note this development without drawing a strong conclusion since it may be transitory, especially considering the unusual economic conditions leading up to the global financial crisis at the end of 2007 (which is also the last year of our data).[51] Indeed, the 1980s exhibited the second weakest productivity-employment relationship of the four decades in our sample, and it was followed immediately by the decade of the 1990s that exhibited a stronger net productivity-employment relationship. These observations underscore that the positive relationship between productivity and employment appears to fluctuate over time, as both the distribution of productivity growth across sectors and its employment elasticities may change over time. Our analysis does not shed light on why these fluctuations occur.

8 Employment growth for whom? The impacts of sectoral productivity growth on skill demands

The evidence presented here indicating that productivity growth has made a modest positive contribution to aggregate employment growth over three and a half decades

[51] Note that we scale our predictions proportionately for the 1970s and 2000s to reflect the incomplete data span for these decades, in order to make their size comparable to model predictions for the other two decades. In follow-up work, we will use a separate EU KLEMS release for 1995-2014 to consider whether this development has persisted or reversed course in the post-crisis years. Preliminary results suggest it may be the latter—though these results are subject to change.

does not imply that these positive employment effects have been evenly distributed across all groups of workers. An uneven distribution of these effects across skill groups can occur for two main reasons. First, it could be that productivity growth leads to a change in the relative demand for skill *within* industries. This could for instance be the case if productivity growth stems from new production techniques or other work practices that skew labor requirements towards more or less skilled workers. Second, sectoral reallocations stemming from unbalanced productivity growth across industries could spur changes in aggregate labor demand by skill group. Because skill-intensity differs substantially across sectors, this reallocation effect on skill demands operates *between* industries. We investigate these two mechanisms in turn.

Table 9 relates changes in countries' industry-level employment shares by skill type (high, medium, and low) to these industries' productivity growth.[52] Our estimates here are akin to those in estimating equation (2), but with the change in skill *shares* as the dependent variables rather than the log change in employment. Like in its counterpart, Table 4, we report both OLS and IV results. We do not find any evidence that productivity growth is skill-biased at the industry level: all estimates are economically small and statistically insignificant. This does not imply that there has been no skill upgrading over the period—indeed, there has been a sizable increase in the share of workers who are high-skilled within *all* industries. Rather, Table 9 indicates that industries experiencing more rapid productivity growth are not differentially changing their skill composition relative to lagging industries.[53]

[52] Although these skill definitions are country-specific, 'high-skilled' broadly corresponds to college graduates, and 'low-skilled' to high-school dropouts (but including high school graduates in some countries), with 'medium-skilled' making up the intermediate range of secondary and lower tertiary degrees in between these two groups. Skill share coverage is lower than overall employment coverage in EU KLEMS, with only Finland, Italy, South Korea, the UK, and the US starting in 1970 (and most other countries starting data coverage around 1980 instead). Table 9 accordingly has fewer observations than found in other tables.

[53] Appendix Table 9a shows that we obtain near-identical results for skill shares when using value-added based labor productivity rather than output-based labor productivity.

Table 9

The effect of productivity growth on employment share by skill type. Dependent variable: Annual change in skill group employment share by country-industry

	High-skilled	Medium-skilled	Low-skilled
		A. OLS	
Δ ln productivity (cit)	-0.003 (0.003)	0.005~ (0.003)	-0.003 (0.002)
Country fixed effects	*YES*	*YES*	*YES*
Year fixed effects	*YES*	*YES*	*YES*
Industry fixed effects	*YES*	*YES*	*YES*
R2	0.068	0.154	0.145
N	13,875	13,875	13,875
		B. IV	
Δ ln productivity (cit)	0.016 (0.018)	0.014 (0.024)	-0.031 (0.023)
Country fixed effects	*YES*	*YES*	*YES*
Year fixed effects	*YES*	*YES*	*YES*
Industry fixed effects	*YES*	*YES*	*YES*
Sanderson-Windmeijer F-statistic	41.2	41.2	41.2
N	13,875	13,875	13,875
		First stage for Δ ln productivity	
Mean Δ ln productivity (it) in other countries	0.270*** (0.042)	0.270*** (0.042)	0.270*** (0.042)

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is measured at the country-industry-year level. All models weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

We next assess how industry productivity growth affects the skill composition of employment by inducing employment shifts across sectors. Since we find unambiguously large and negative Baumol effects in every sector—whereby industry productivity growth reduces own-industry employment—our estimates imply that sectoral productivity growth will be non-neutral for employment by skill group: productivity growth in relatively low-skill intensive sectors will diminish economy-wide relative demand for low-skill workers, while productivity growth in relatively high-skill intensive sectors will reduce economy-wide demand for high-skill workers.[54] Appendix Table 9a shows that different sectors are indeed differently skill intensive, with education and health, and high-tech services having the highest shares of high-skilled workers, and low-tech services relying more on low-skilled workers. Such skill-biases can potentially be quite large, even when the net employment implications of productivity growth are modest.

To quantify the non-neutrality of productivity growth for employment by skill, we calculate a variant of equation (5) above where we scale predicted employment

54 A second source of non-neutrality results from the fact that sectoral productivity growth is calculated as a leave-out mean that excludes own-industry productivity growth for industries within the sector. This means that the external effects of productivity growth from a given sector will depend in part on which industries within the sector contribute most or least to sectoral productivity growth. In practice, this non-neutrality makes little difference for our calculations; almost the entirety of the estimated non-neutrality stems from the internal rather than external effects of productivity growth.

growth by industry as a function of both internal and external productivity growth by the average share of industry employment comprised by low-, middle-, and high-education workers, indexed below by the superscript q:

$$\Delta\hat{E}^{q}_{ict} = \left\{E^{q}_{ic,t=base} \times 1(i \in s) \times \hat{\beta}_{1,s(i)} \times \Delta\ln LP_{ict}\right\} + \left\{E^{q}_{ic,t=base} \times \sum_{s(i)=1}^{5}\sum_{k=0}^{3}\hat{\beta}_{2+k,s(i)} \times \Delta\ln\widetilde{LP}_{ct-k,j\neq i}\right\} \quad [8]$$

Paralleling our earlier calculations for aggregate employment, we normalize these predicted employment impacts by the base employment level of each skill group in each country to obtain implied proportional impacts. This scaling also accounts for the fact that the three major skill groups are not typically equally large, so for example, a projected employment gain of one million workers in each skill category would imply larger proportional growth for smaller skill groups.

Results averaged across all 19 countries are shown in Figure 8. Employment growth has been strongly skill-biased, with productivity-driven employment growth for high-skilled workers substantially exceeding that for both medium- and low-skill workers since 1980. This diverging pattern shows no signs of abatement in the later years of our sample and is equally visible when using value-added per worker as a productivity measure (see Appendix Figure 8).

Considering these predictions separately for the ‘big 5’ countries, reported in Figure 9, we find that this pattern is near-universal, with two exceptions: Japan, which based on its skill shares has (by our calculations) witnessed a strong increase in low-skilled work; and the US, where high- and low-skilled workers have seen almost identical percentage increases in demand whereas middle-skill demand has lagged, consistent with employment polarization. Appendix Figure 9 reports qualitatively identical results for value-added based productivity growth. Thus, despite productivity growth not being inimical to employment in net, it has been decidedly friendlier towards high-skilled employment than towards low- or middle-skill employment.

Figure 8

Predicted cumulative percentage employment change by skill group from productivity growth originating in five sectors

(x-axis: year; y-axis: cumulative predicted change (%))

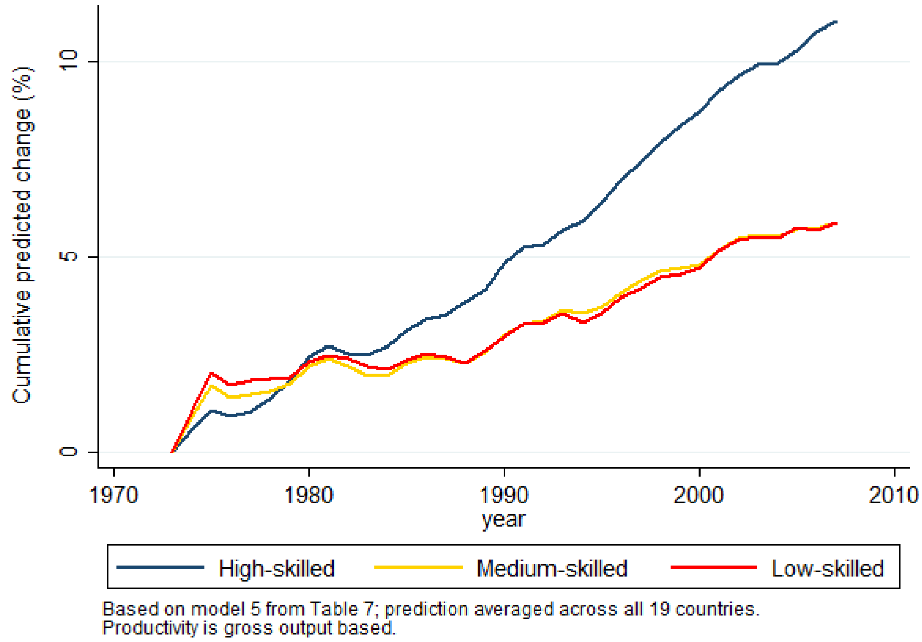
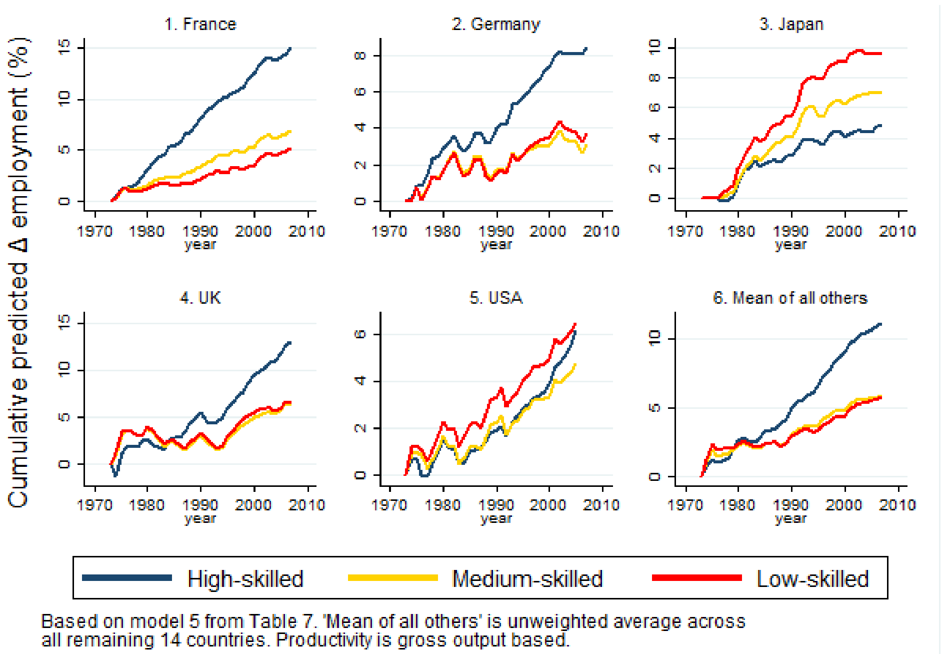


Figure 9

Predicted cumulative percentage employment change by skill group from productivity growth originating in five sectors: Results by country

(x-axis: year; y-axis: cumulative predicted Δ employment (%)



9 Concluding remarks

Has productivity growth threatened employment? Over the 35-year period we considered, the answer has been no—or perhaps more memorably, 'Robocalypse *no*.' Aggregate productivity growth has been employment-augmenting in this period. This is true despite robust evidence—consistent with popular perceptions—that industries experiencing rising labor productivity exhibit falling employment. As such, the evidence does not support the optimistic scenario in which industry-level productivity gains *raise* own-industry employment—though this optimistic scenario has doubtless been true in specific sectors and time periods (Bessen, 2017). Yet, this case is neither necessary nor sufficient for industry- or sector-level productivity gains to be employment-augmenting in net. Provided that productivity growth in one sector generates sufficiently large positive spillovers to employment growth elsewhere in the economy—operating through what is likely a combination of income effects and inter-industry demand linkages—then this productivity growth can still be employment-augmenting, even if it reduces employment in the sector in which it occurs. This latter scenario is supported by our analysis: over the nearly four decades that we study, the external effects of sectoral productivity growth on aggregate employment have been sufficiently powerful to more than fully offset employment contractions occurring in sectors making strong productivity gains.

Sectoral productivity growth does, however, have strongly heterogeneous external employment effects, with the most positive stemming from productivity growth in health, education, and the other services, and the least positive effects emanating from productivity growth in utilities, mining, and construction. The source of productivity growth therefore matters for its aggregate employment consequences. Given that service sector productivity growth in particular appears to have strong employment spillovers, our findings suggest that the spread of robotics and other productivity-augmenting technologies into services may prove a *net positive* for employment growth.

Two observations temper this conclusion, however: first, productivity growth is slower in services than outside of it; second, the own-sector effects of productivity growth on sectoral employment have become more negative in recent decades while the external effects of productivity growth on other-sector employment have become less positive. This suggests a weakening of the virtuous relationship between productivity growth and employment growth. This weakening is most pronounced in the manufacturing sector, suggesting the possibility that increased trade openness has led part of the increased domestic demand following productivity growth to be met by foreign producers—thus moderating the positive domestic employment response from increased product demand. This is a hypothesis we will explore in future work.

Lastly, we establish that for understanding countries' employment trajectories, population growth is a much more important contributor to employment growth than is productivity growth. Yet the profound sectoral reallocations implied by productivity growth—away from high-productivity sectors such as utilities and manufacturing, and towards tertiary sectors—have important consequences for the distribution of employment growth, and likely also the gains from employment. Specifically, these productivity-induced sectoral shifts are shown to be sharply biased in favor of skilled workers. In this respect, our analysis underscores a central insight of much recent work on the labor market impacts of technological progress: the primary societal challenge posed so far by these advances far is not falling aggregate labor demand but, rather, an increasingly skewed distribution of employment—and ultimately earnings—favoring highly educated workers.

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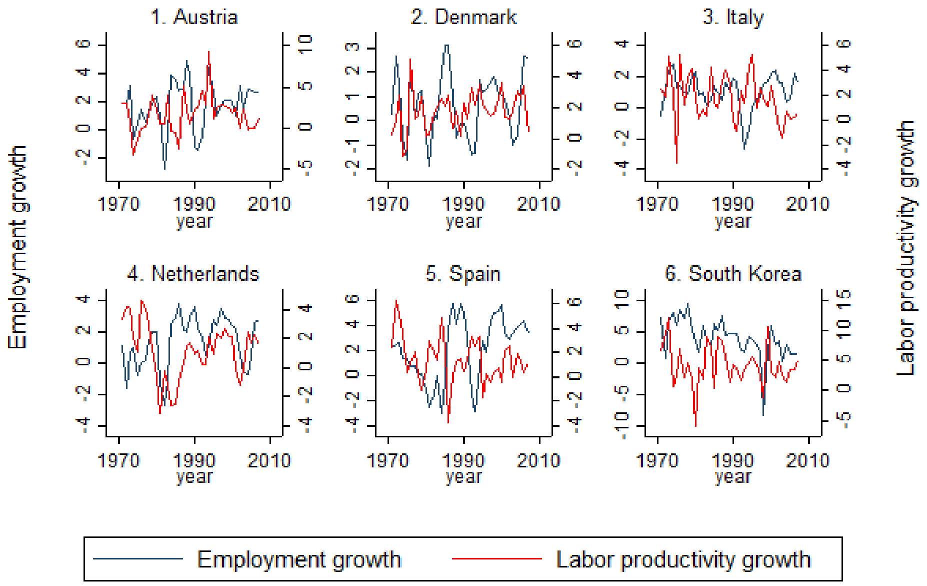
10 Appendix Figures

Figure A1a

Employment and productivity growth, 1970-2007: Results for additional countries

(x-axis: year; y-axis: employment growth (left-hand scale), labor productivity growth (right-hand scale))

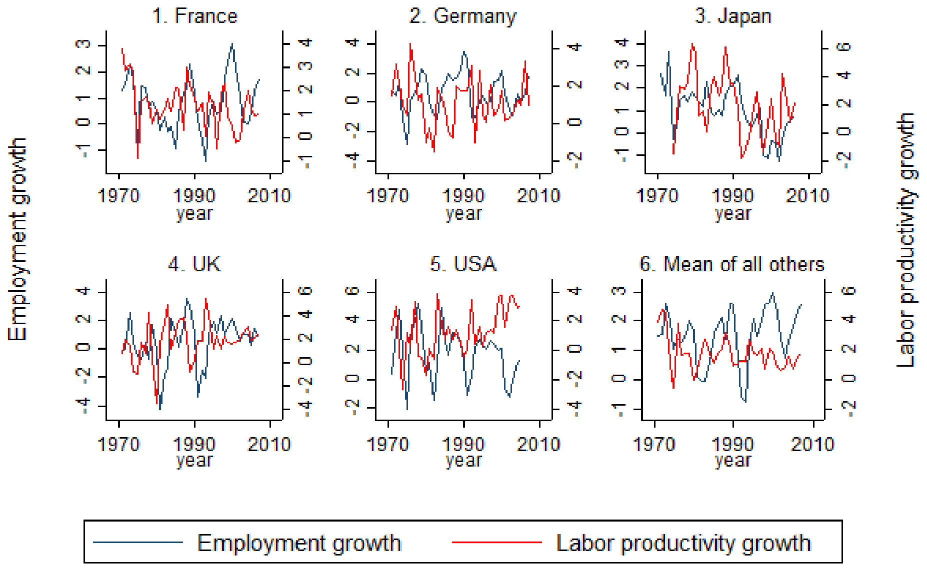


Figures are for the total economy, excluding agriculture, public administration, private households and extraterritorial organizations. All growth rates obtained as log changes x 100. Productivity is gross output per worker.

Figure A1b

Employment and value-added based productivity growth, 1970-2007

(x-axis: year; y-axis: employment growth (left-hand scale), labor productivity growth (right-hand scale))

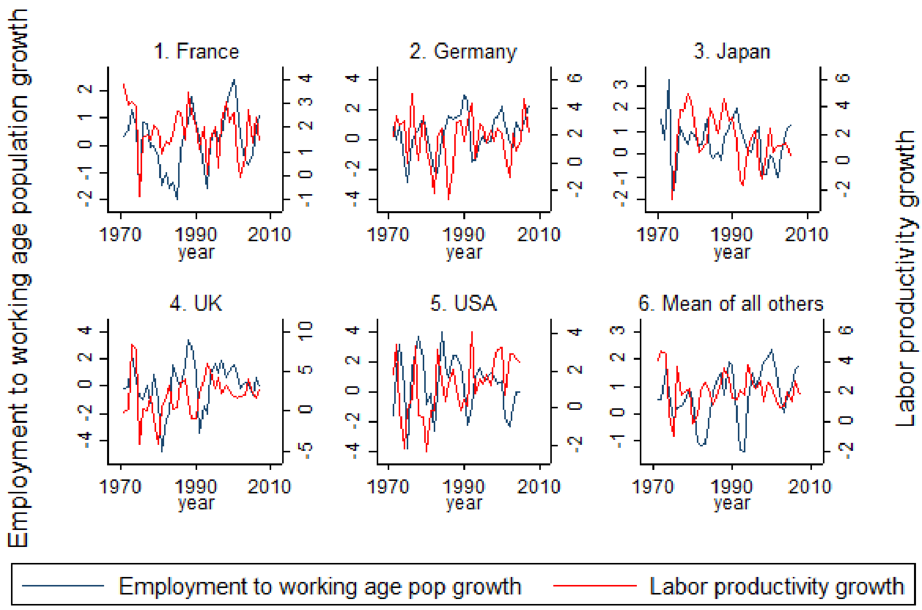


Figures are for the total economy, excluding agriculture, public administration, private households and extraterritorial organizations. All growth rates obtained as log changes x 100. Graph 6 reports unweighted mean growth rates across the remaining 14 countries. Productivity is value added per worker.

Figure A1c

Employment rate and productivity growth, 1970-2007

(x-axis: year; y-axis: employment to working age population growth (left-hand scale), labor productivity growth (right-hand scale))

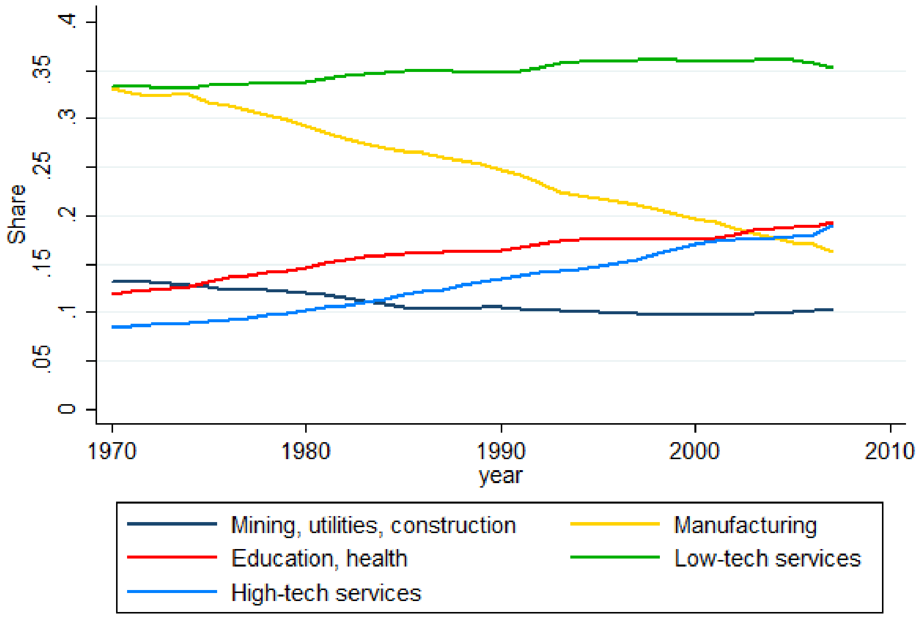


Figures are for the total economy, excluding agriculture, public administration, private households and extraterritorial organizations. All growth rates obtained as log changes x 100. Graph 6 reports unweighted mean growth rates across the remaining 14 countries. Productivity is gross output per worker.

Figure A2a

Employment shares by sector, 1970-2007

(x-axis: year; y-axis: share)

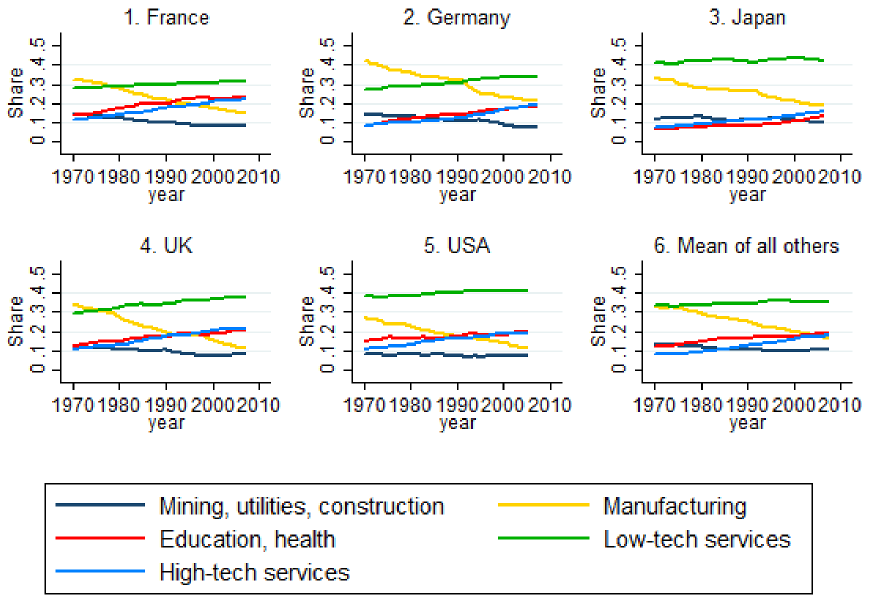


Unweighted average across all 19 countries.

Figure A2b

Employment shares by sector, 1970-2007: Large countries

(x-axis: year; y-axis: share)

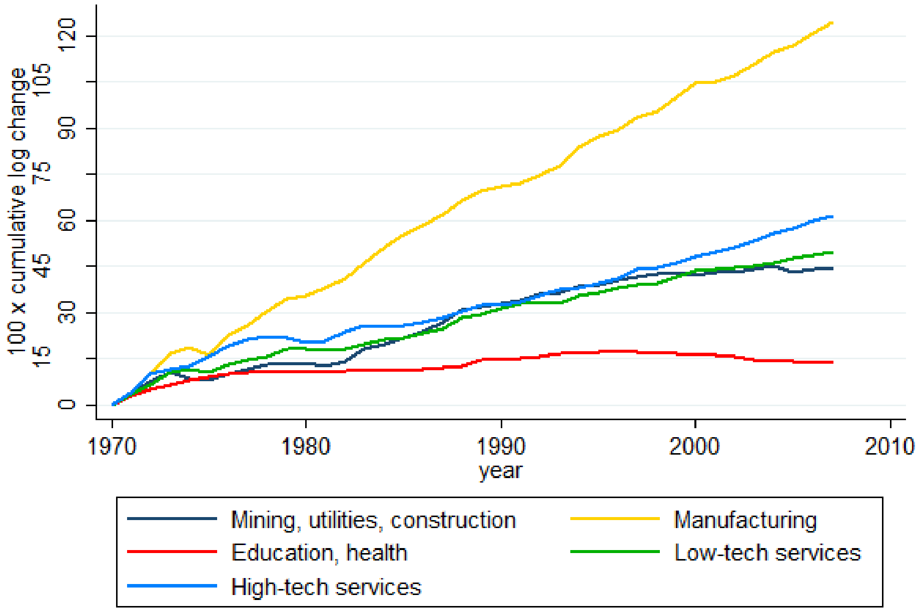


Mean of all others is an unweighted average.

Figure A3a

Cumulative log value-added based labor productivity growth by sector, 1970-2007

(x-axis: year; y-axis: 100 x cumulative log change)

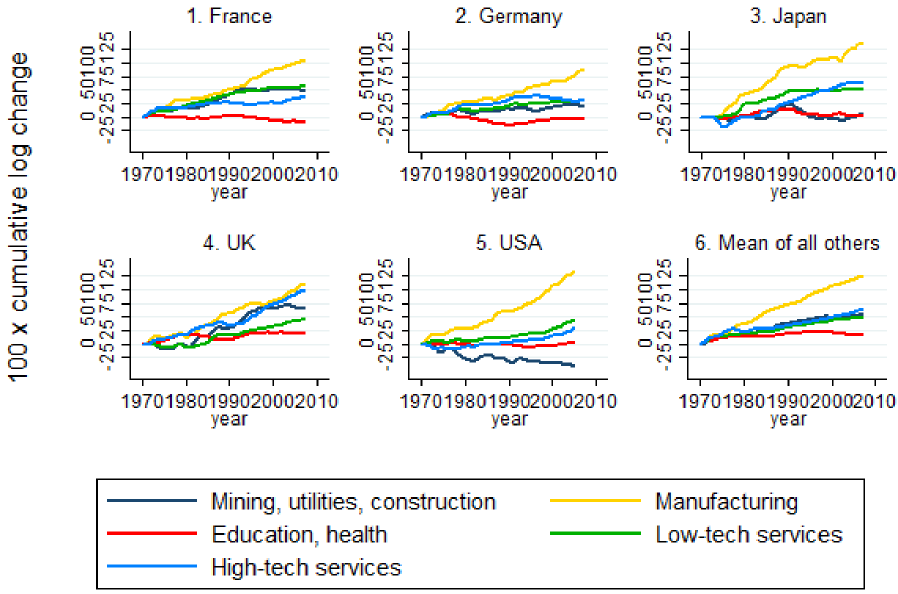


Unweighted average across all 19 countries. Productivity is value added based.

Figure A3b

Cumulative log value-added based labor productivity growth by sector, 1970-2007: Large countries

(x-axis: year; y-axis: 100 x cumulative log change)

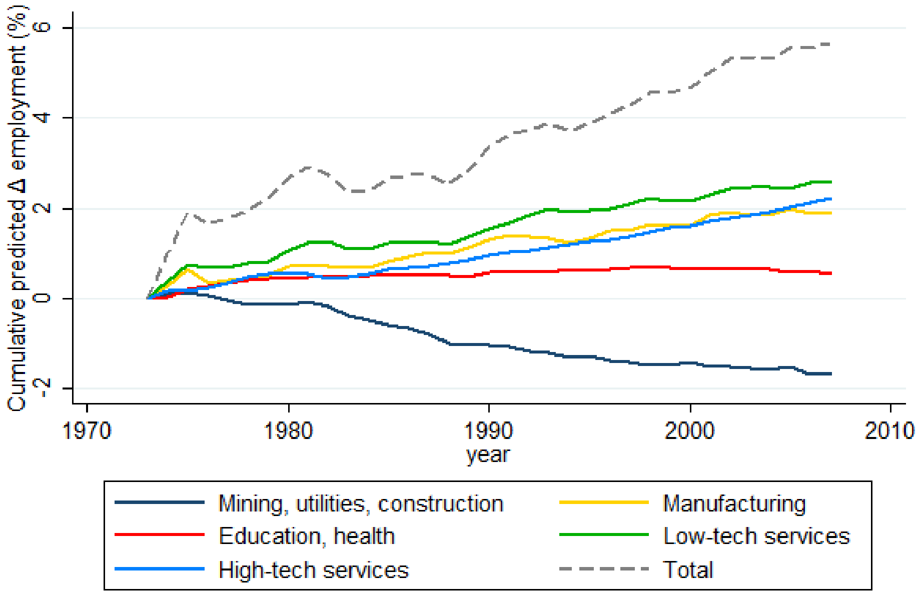


Mean of all others is an unweighted average. Productivity is value added based.

Figure A4

Predicted cumulative percentage employment change from value-added based productivity growth originating in five sectors, summing own-industry and spillover effects

(x-axis: year; y-axis: cumulative predicted Δ employment (%))

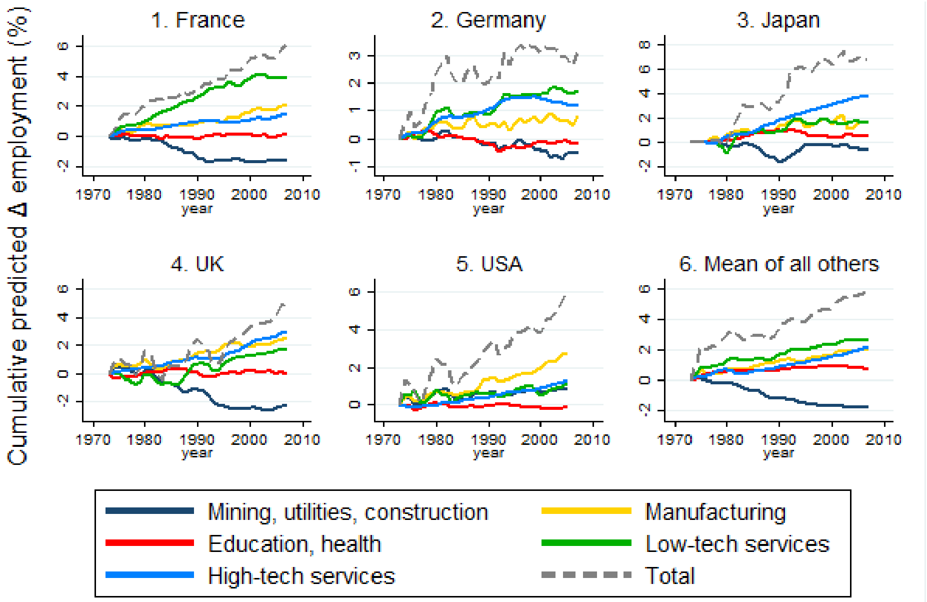


Based on model 5 from Table 7; prediction averaged across all 19 countries.
Productivity is value added based.

Figure A5

Predicted cumulative percentage employment change from value-added based productivity growth originating in five sectors, summing own-industry and spillover effects: Large countries

(x-axis: year; y-axis: cumulative predicted Δ employment (%))

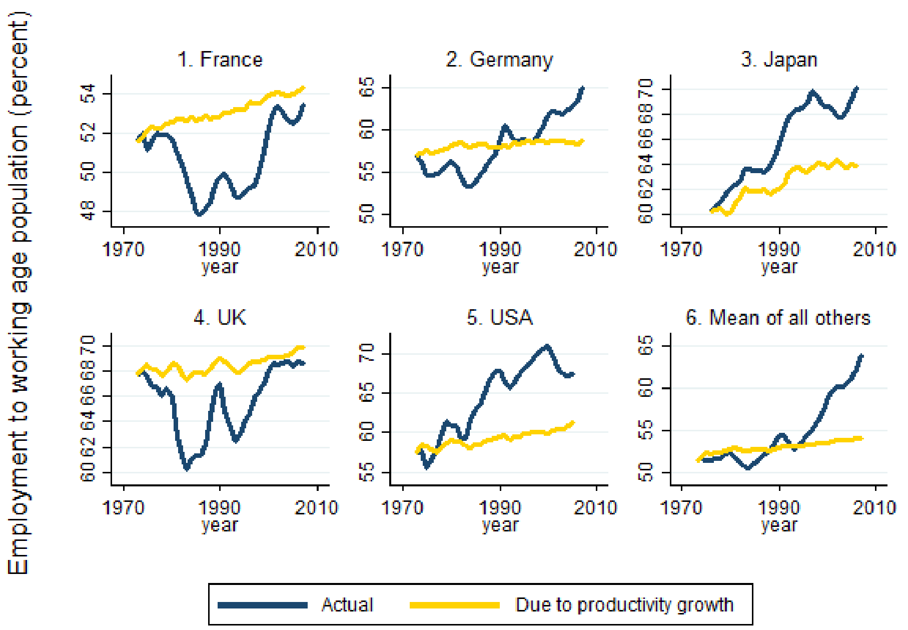


Based on model 5 from Table 7. Productivity is value added based.

Figure A6a

Comparing the estimated effects of value-added based productivity growth on employment rate growth to the evolution of employment rates by country, 1970-2007: Large countries

(x-axis: year; y-axis: employment to working age population (percent))

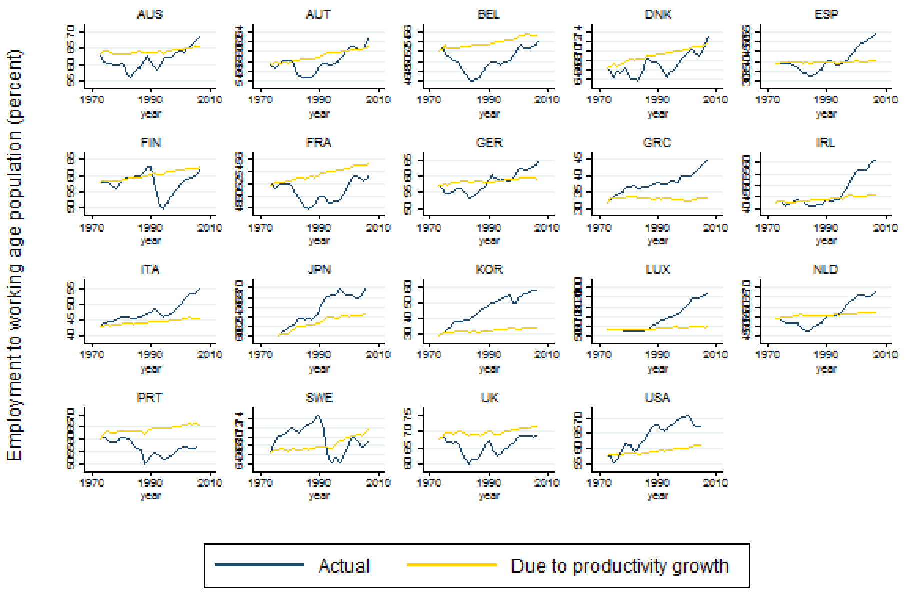


Figures are for the total economy, excluding agriculture, public administration, private households and extraterritorial organizations. Productivity is value added per worker.

Figure A6b

Comparing the estimated effects of productivity growth on employment rate growth to the evolution of employment rates by country, 1970-2007: Individual countries

(x-axis: year; y-axis: employment to working age population (percent))

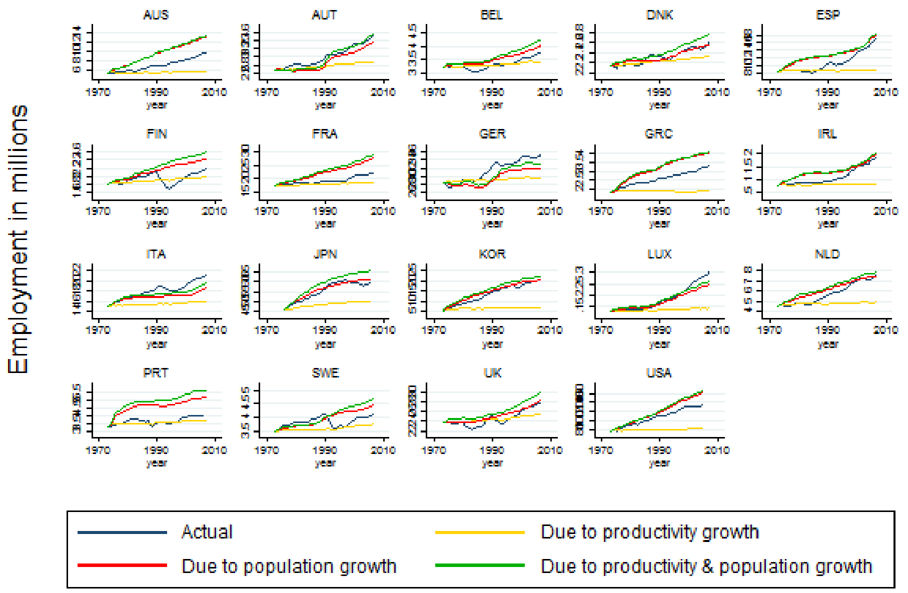


Figures are for the total economy, excluding agriculture, public administration, private households and extraterritorial organizations.
Productivity is gross output per worker.

Figure A6c

Comparing the estimated effects of productivity growth and population growth to the evolution of employment by country, 1970-2007: Individual countries

(x-axis: year; y-axis: employment in millions)

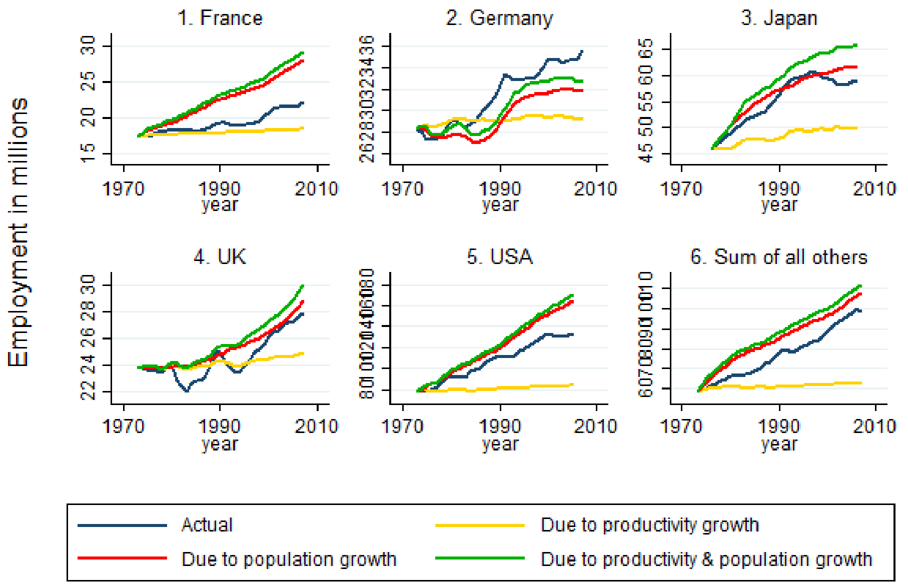


Figures are for the total economy, excluding agriculture, public administration, private households and extraterritorial organizations.
Productivity is gross output based.

Figure A6d

Comparing the estimated effects of value-added based productivity growth and population growth to the evolution of employment by country, 1970-2007: Large countries

(x-axis: year; y-axis: employment in millions)

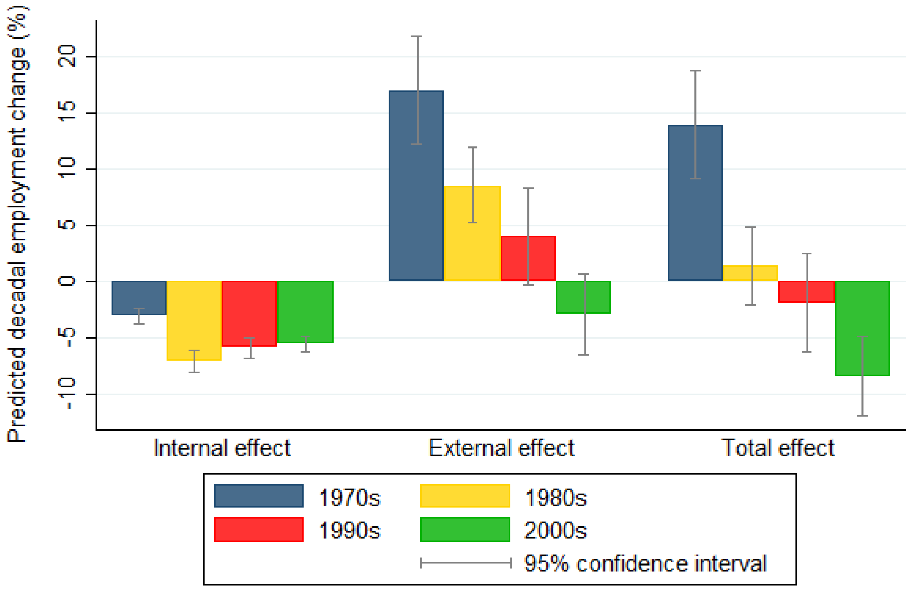


Figures are for the total economy, excluding agriculture, public administration, private households and extraterritorial organizations.
Productivity is value added based.

Figure A7

Predicted cumulative percentage employment change by decade from value-added based productivity growth originating in five sectors

(y-axis: predicted decadal employment change (%))



Based on sector-specific model from Table 8. Predictions for the 1970s and 2000s scaled up to be comparable to the 1980s and 1990s. Confidence interval constructed by bootstrapping predictions (1,000 repetitions). Productivity is value added per worker.

Figure A8

Predicted cumulative percentage employment change by skill group from value-added based productivity growth originating in five sectors

(x-axis: year; y-axis: cumulative predicted change (%))

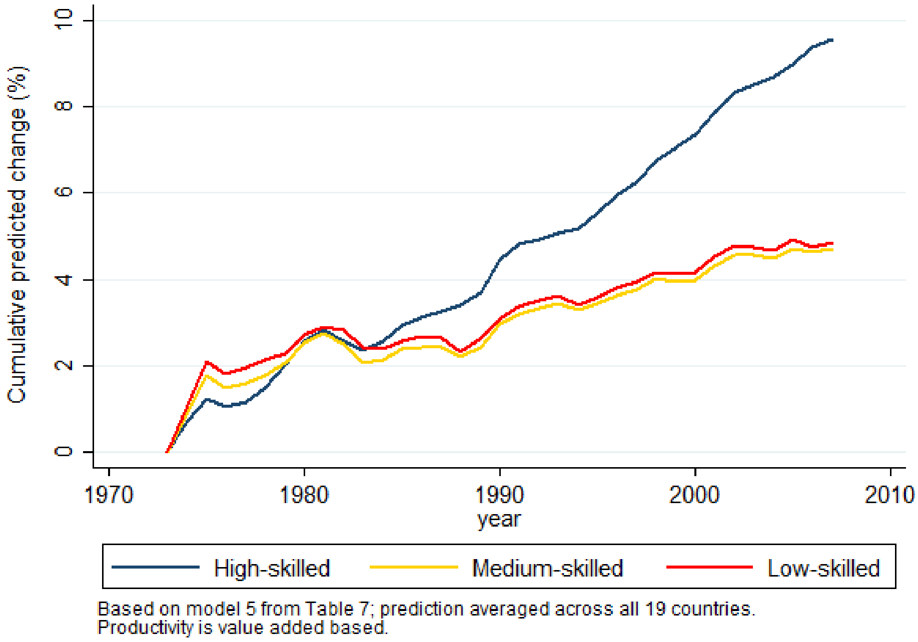
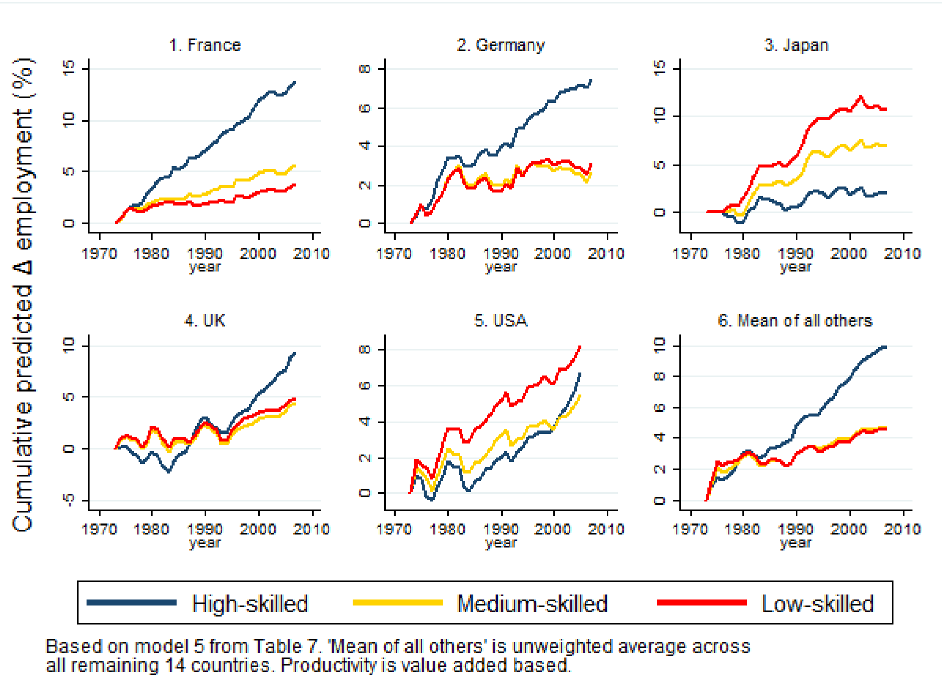


Figure A9

Predicted cumulative percentage employment change by skill group from value-added based productivity growth originating in five sectors: Large countries

(x-axis: year; y-axis: cumulative predicted Δ employment(%))



11 Appendix Tables

Table A1

EU KLEMS data coverage: Industries

ISIC code	Description
AtB	Agriculture, hunting, forestry, and fishing
C	Mining and quarrying
15t16	Food, beverages, and tobacco
17t19	Textiles, textile, leather, and footwear
20	Wood and wood products
21t22	Pulp, paper, paper, printing, and publishing
23	Coke, refined petroleum and nuclear fuel
24	Chemicals and chemical products
25	Rubber and plastics
26	Other non-metallic mineral
27t28	Basic metals and fabricated metal
29	Machinery, not elsewhere classified
30t33	Electrical and optical equipment
34t35	Transport equipment
36t37	Manufacturing not elsewhere classified; recycling
E	Electricity, gas, and water supply
F	Construction
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
52	Retail trade, except of motor vehicles and motorcycles; repair of household goods
H	Hotels and restaurants
60t63	Transport and storage
64	Post and telecommunications
J	Financial intermediation
70	Real estate activities
71t74	Renting of machinery & equipment and other business activities
L	Public admin and defense; compulsory social security
M	Education
N	Health and social work
O	Other community, social and personal service activities
P	Private households with employed persons
Q	Extra-territorial organizations and bodies

Notes: ISIC revision 3 codes. We exclude agriculture (industry AtB), public administration (industry L), and private households (P) and extra-territorial organizations (Q) from our analyses. Industries 15t16 through 36t37 are manufacturing industries.

Table A2

Average annualized growth in employment and productivity by industry

ISIC code	Description	Δ log employment	Δ log gross output per worker	Δ log value added per worker	Δ Total Factor Productivity
C	Mining and quarrying	-2.47	3.67	3.61	0.18
15t16	Food, beverages, and tobacco	-0.44	2.33	2.22	0.53
17t19	Textiles, textile, leather, and footwear	-3.57	3.27	3.14	1.68
20	Wood and wood products	-0.60	2.75	2.92	1.96
21t22	Pulp, paper, paper, printing, and publishing	-0.20	3.12	2.76	0.83
23	Coke, refined petroleum and nuclear fuel	-0.79	2.95	3.69	-2.87
24	Chemicals and chemical products	-0.20	4.42	4.80	2.24
25	Rubber and plastics	0.52	3.51	3.63	2.16
26	Other non-metallic mineral	-1.00	3.16	3.02	1.41
27t28	Basic metals and fabricated metal	-0.39	3.01	2.82	1.24
29	Machinery, not elsewhere classified	-0.05	3.38	3.09	1.58
30t33	Electrical and optical equipment	0.20	5.64	6.08	5.98
34t35	Transport equipment	-0.02	3.69	3.31	2.31
36t37	Manufacturing not elsewhere classified; recycling	-0.22	2.80	2.30	1.08
E	Electricity, gas, and water supply	0.08	3.82	3.58	1.06
F	Construction	0.85	1.19	0.83	0.08
50	Sale, maintenance and repair of motor vehicles; retail sale of fuel	1.32	1.91	1.35	0.16
51	Wholesale trade and commission trade, except of motor vehicles	1.31	2.11	2.18	0.98
52	Retail trade, except of motor vehicles; repair of household goods	1.31	1.71	1.59	1.11
H	Hotels and restaurants	2.13	0.37	-0.21	-0.80
60t63	Transport and storage	1.11	2.78	2.38	1.01
64	Post and telecommunications	0.85	6.03	5.62	3.39
J	Financial intermediation	2.20	3.05	2.56	1.16
70	Real estate activities	3.50	-0.13	-0.14	-0.42
71t74	Renting of machinery & equipment and other business activities	5.03	0.39	0.02	-1.61
M	Education	2.09	0.58	0.37	-0.23
N	Health and social work	3.12	0.84	0.49	-0.42
O	Other community, social and personal service activities	2.48	0.73	0.29	-1.28

Notes: Employment is total number of persons engaged. TFP is value added based. Unweighted averages across all countries where data is available, using annualized changes. Excludes agriculture, public administration, private households, and extra-territorial organizations.

Table A3

First stages for Instrumental Variables models in Tables 3a and 3b

	(1)	(2)	(3)	(4)	(5)	(6)
	First stage for Δ ln productivity (c, t)					
Mean Δ ln productivity (t) in other countries	0.758** (0.080)	0.781** (0.077)	0.641** (0.102)	0.686** (0.099)	0.639** (0.103)	0.673** (0.099)
Mean Δ ln productivity (t-1) in other countries	-	-	-0.013 (0.092)	0.012 (0.089)	-0.013 (0.092)	0.013 (0.089)
Mean Δ ln productivity (t-2) in other countries	-	-	-0.093 (0.092)	-0.071 (0.089)	-0.093 (0.092)	-0.068 (0.088)
Mean Δ ln productivity (t-3) in other countries	-	-	-0.053 (0.085)	-0.025 (0.082)	-0.051 (0.085)	-0.011 (0.082)
Δ ln population (ct)	-	-	-	-	-0.052 (0.170)	-0.403~ (0.221)
	First stage for Δ ln productivity (c, t-1)					
Mean Δ ln productivity (t) in other countries	-	-	-0.099 (0.106)	-0.053 (0.102)	-0.101 (0.106)	-0.064 (0.102)
Mean Δ ln productivity (t-1) in other countries	-	-	0.719** (0.095)	0.746** (0.092)	0.719** (0.095)	0.746** (0.092)
Mean Δ ln productivity (t-2) in other countries	-	-	0.001 (0.095)	0.024 (0.091)	0.001 (0.095)	0.027 (0.091)
Mean Δ ln productivity (t-3) in other countries	-	-	-0.080 (0.088)	-0.050 (0.085)	-0.079 (0.088)	-0.039 (0.085)
Δ ln population (ct)	-	-	-	-	-0.038 (0.175)	-0.328 (0.228)
	First stage for Δ ln productivity (c, t-2)					
Mean Δ ln productivity (t) in other countries	-	-	-0.123 (0.106)	-0.077 (0.103)	-0.116 (0.107)	-0.076 (0.103)
Mean Δ productivity (t-1) in other countries	-	-	-0.013 (0.096)	0.014 (0.092)	-0.013 (0.096)	0.014 (0.092)
Mean Δ ln productivity (t-2) in other countries	-	-	0.719** (0.096)	0.743** (0.092)	0.718** (0.096)	0.743** (0.092)
Mean Δ ln productivity (t-3) in other countries	-	-	0.004 (0.089)	0.035 (0.085)	-0.003 (0.089)	0.034 (0.086)
Δ ln population (ct)	-	-	-	-	0.211 (0.177)	0.053 (0.230)
	First stage for Δ ln productivity (c, t-3)					
Mean Δ ln productivity (t) in other countries	-	-	-0.087 (0.109)	-0.040 (0.105)	-0.074 (0.109)	-0.034 (0.105)
Mean Δ ln productivity (t-2) in other countries	-	-	-0.077 (0.098)	-0.049 (0.095)	-0.077 (0.098)	-0.050 (0.095)
Mean Δ ln productivity (t-2) in other countries	-	-	0.002 (0.098)	0.026 (0.094)	0.000 (0.098)	0.024 (0.094)
Mean Δ ln productivity (t-3) in other countries	-	-	0.734** (0.091)	0.766** (0.087)	0.723** (0.091)	0.760** (0.088)
Δ ln population (ct)	-	-	-	-	0.342~ (0.181)	0.183 (0.236)

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. All models estimate stacked annual differences over 1970-2007 for the total economy. The number of observations is equal to the number of countries multiplied by the number of years. Standard errors in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

Table A4

The contemporaneous and lagged effects of productivity growth on employment growth at the industry level. Dependent variable: Annual log change in employment by country-industry

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	A. OLS							
Δ ln productivity (ci, t)	-0.254** (0.025)	-0.263** (0.025)	-0.276** (0.026)	-0.251** (0.025)	-0.255** (0.026)	-0.263** (0.025)	-0.274** (0.026)	-0.249** (0.026)
Δ ln productivity (ci, t-1)	0.035** (0.012)	0.026* (0.011)	0.013 (0.011)	0.037** (0.010)	0.033** (0.012)	0.026* (0.011)	0.014 (0.011)	0.037** (0.010)
Δ ln productivity (ci, t-2)	-	-	-	-	-0.001 (0.012)	-0.010 (0.011)	-0.016 (0.011)	0.008 (0.010)
Country fixed effects	*NO*	*YES*	*YES*	*YES*	*NO*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*	*NO*	*NO*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*	*NO*	*NO*	*NO*	*YES*
R2	0.113	0.154	0.200	0.302	0.112	0.155	0.200	0.306
N	18,920	18,920	18,920	18,920	18,389	18,389	18,389	18,389
	B. IV							
Δ ln productivity (ci, t)	-0.264** (0.069)	-0.265** (0.061)	-0.333** (0.096)	0.026 (0.109)	-0.268** (0.071)	-0.267** (0.062)	-0.262** (0.096)	0.003 (0.109)
Δ ln productivity (ci, t-1)	-0.076 (0.061)	-0.078 (0.054)	-0.260** (0.088)	0.078 (0.091)	0.065 (0.081)	0.063 (0.071)	-0.032 (0.120)	0.113 (0.099)
Δ ln productivity (ci, t-2)	-	-	-	-	-0.241** (0.070)	-0.242** (0.063)	-0.371** (0.096)	-0.097 (0.083)
Country fixed effects	*NO*	*YES*	*YES*	*YES*	*NO*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*	*NO*	*NO*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*	*NO*	*NO*	*NO*	*YES*
Sanderson-Windmeijer F-stat	127.8	127.1	37.5	46.4	136.1	135.3	41.4	47.6
N	18,920	18,920	18,920	18,920	18,389	18,389	18,389	18,389

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is measured at the country-industry-year level. All models weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

Table A5a

Cyclical peaks and troughs for the 19 countries in our sample, 1970-2007

	Peaks	Troughs
AUS	1970, 1973, 1976, 1981, 1985, 1989, 1994, 2000, 2002	1972, 1975, 1978, 1983, 1986, 1991, 1996, 2001, 2003
AUT	1970, 1974, 1977, 1980, 1983, 1986, 1991, 1995, 2000	1971, 1975, 1978, 1981, 1984, 1988, 1993, 1997, 2003
BEL	1970, 1974, 1976, 1980, 1984, 1990, 1994, 1997, 2000, 2004	1971, 1975, 1977, 1983, 1987, 1993, 1996, 1998, 2003, 2005
DNK	1973, 1976, 1979, 1986, 1989, 1992, 1994, 1997, 2000, 2006	1971, 1975, 1978, 1981, 1987, 1991, 1993, 1995, 1998, 2003
ESP	1974, 1978, 1980, 1983, 1991, 1995, 2000	1971, 1975, 1979, 1981, 1986, 1993, 1996, 2004
FIN	1970, 1973, 1980, 1985, 1990, 1995, 1998, 2000, 2007	1971, 1978, 1984, 1987, 1993, 1996, 1999, 2003
FRA	1971, 1974, 1979, 1982, 1990, 1995, 2000, 2007	1972, 1975, 1981, 1987, 1993, 1997, 2003
GER	1970, 1973, 1979, 1985, 1991, 1995, 2001	1972, 1975, 1982, 1987, 1993, 1996, 2005
GRC	1973, 1979, 1985, 1989, 1991, 1994, 1998, 2004	1974, 1983, 1987, 1990, 1993, 1996, 2002, 2005
IRL	1972, 1975, 1978, 1982, 1985, 1990, 1995, 2000, 2007	1971, 1974, 1976, 1980, 1983, 1986, 1994, 1996, 2003
ITA	1970, 1974, 1976, 1979, 1985, 1989, 1995, 2001	1972, 1975, 1977, 1983, 1987, 1993, 1999, 2003
JPN	1973, 1979, 1982, 1985, 1990, 1997, 2001	1975, 1980, 1983, 1987, 1994, 1999, 2002
KOR	1971, 1973, 1979, 1984, 1988, 1991, 1997, 2000, 2002, 2007	1972, 1975, 1980, 1986, 1989, 1992, 1998, 2001, 2005
LUX	1974, 1979, 1984, 1986, 1989, 1991, 1994, 2000, 2007	1971, 1975, 1983, 1985, 1987, 1990, 1992, 1996, 2005
NLD	1970, 1974, 1976, 1979, 1986, 1990, 1994, 2000	1972, 1975, 1977, 1982, 1987, 1993, 1996, 2005
PRT	1970, 1973, 1977, 1980, 1983, 1990, 2001, 2004	1972, 1975, 1978, 1981, 1984, 1993, 2003, 2005
SWE	1970, 1974, 1980, 1984, 1990, 1995, 2000, 2007	1972, 1977, 1983, 1986, 1993, 1997, 2003
UK	1973, 1979, 1983, 1988, 1994, 1997, 2000, 2003	1970, 1975, 1981, 1984, 1992, 1996, 1999, 2002, 2004
USA	1973, 1978, 1985, 1989, 1994, 2000	1970, 1975, 1982, 1987, 1991, 1995, 2003

Notes: Based on OECD data.

Table A5b

The effects of industry and aggregate productivity growth on employment growth over the business cycle. Dependent variable: Annual log peak-to-peak change in employment by country-industry

	(1)	(2)	(3)	(4)	(5)
Δ ln productivity (cit)	-0.317** (0.030)	-0.325** (0.029)	-0.329** (0.029)	-0.247** (0.027)	-0.244** (0.027)
Δ ln productivity (c, j≠i, t)	-0.098 (0.196)	-0.257 (0.159)	-0.073 (0.142)	-0.113 (0.138)	-0.038 (0.121)
Δ ln productivity (c, j≠i, t-1)	0.350* (0.155)	0.366** (0.129)	0.020 (0.162)	0.014 (0.160)	-0.009 (0.162)
Δ ln productivity (c, j≠i, t-2)	0.261~ (0.134)	0.284~ (0.149)	0.203 (0.174)	0.183 (0.174)	0.161 (0.163)
Δ ln productivity (c, j≠i, t-3)	0.144 (0.116)	0.057 (0.102)	0.182~ (0.106)	0.182~ (0.098)	0.179~ (0.094)
Δ ln total population (ct)	-	-	-	-	1.257** (0.382)
Country fixed effects	*NO*	*YES*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*	*YES*
R2	0.148	0.209	0.258	0.474	0.485
N	3,520	3,520	3,520	3,520	3,520
Σk Δ ln productivity (c, j≠i, t-k)	0.658** (0.154)	0.449** (0.120)	0.332** (0.108)	0.265* (0.104)	0.293** (0.098)
Σk Δ ln productivity (c, j≠i, t-k) + Δ ln productivity (cit)	0.340** (0.161)	0.124 (0.126)	0.003 (0.112)	0.018 (0.111)	0.048 (0.104)

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is measured at the country-industry-year level; aggregate productivity is the country-year level productivity with the own industry netted out. All models estimated with OLS and weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of peak-to-peak periods. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

Table A5c

The effects of industry and aggregate productivity growth on employment growth over the business cycle. Dependent variable: Annual log trough-to-trough change in employment by country-industry

	(1)	(2)	(3)	(4)	(5)
Δ ln productivity (cit)	-0.328** (0.036)	-0.333** (0.035)	-0.333** (0.036)	-0.225** (0.036)	-0.225** (0.036)
Δ ln productivity (c, j≠i, t)	-0.016 (0.253)	-0.031 (0.173)	0.169 (0.233)	0.084 (0.231)	-0.034 (0.213)
Δ ln productivity (c, j≠i, t-1)	0.765* (0.321)	0.705** (0.195)	0.328 (0.315)	0.326 (0.305)	0.523~ (0.280)
Δ ln productivity (c, j≠i, t-2)	-0.371~ (0.213)	-0.405** (0.135)	-0.240 (0.197)	-0.237 (0.192)	-0.311~ (0.171)
Δ ln productivity (c, j≠i, t-3)	0.273~ (0.162)	0.183 (0.111)	0.246~ (0.138)	0.232~ (0.138)	0.206~ (0.119)
Δ ln total population (ct)	-	-	-	-	1.477** (0.387)
Country fixed effects	*NO*	*YES*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*	*YES*
R2	0.156	0.217	0.251	0.475	0.485
N	3,353	3,353	3,353	3,353	3,353
Σk Δ ln productivity (c, j≠i, t-k)	0.651** (0.141)	0.451** (0.101)	0.503** (0.104)	0.406** (0.103)	0.384** (0.096)
Σk Δ ln productivity (c, j≠i, t-k) + Δ ln productivity (cit)	0.323* (0.148)	0.119 (0.112)	0.170 (0.118)	0.181 (0.119)	0.160 (0.112)

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is measured at the country-industry-year level; aggregate productivity is the country-year level productivity with the own industry netted out. All models estimated with OLS and weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of trough-to-trough periods. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

Table A5d

The effects of industry and aggregate value-added based productivity growth on employment growth. Dependent variable: Annual log change in employment by country-industry

	(1)	(2)	(3)	(4)	(5)
Δ ln productivity (cit)	-0.265** (0.023)	-0.266** (0.023)	-0.269** (0.023)	-0.243** (0.023)	-0.243** (0.023)
Δ ln productivity (c, j≠i, t)	0.163* (0.069)	0.140* (0.066)	0.083 (0.064)	0.062 (0.063)	0.076 (0.061)
Δ ln productivity (c, j≠i, t-1)	0.177** (0.046)	0.160** (0.038)	0.102** (0.036)	0.094** (0.035)	0.109** (0.034)
Δ ln productivity (c, j≠i, t-2)	0.131** (0.046)	0.111** (0.039)	0.092* (0.038)	0.087* (0.037)	0.086* (0.036)
Δ ln productivity (c, j≠i, t-3)	0.130** (0.041)	0.100** (0.034)	0.096** (0.033)	0.090** (0.033)	0.085** (0.032)
Δ ln total population (ct)	-	-	-	-	1.104** (0.197)
Country fixed effects	*NO*	*YES*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*	*YES*
R2	0.147	0.178	0.209	0.315	0.322
N	17,858	17,858	17,858	17,858	17,858
Σk Δ ln productivity (c, j≠i, t-k)	0.601** (0.097)	0.511** (0.095)	0.373** (0.090)	0.333** (0.089)	0.356** (0.086)
Σk Δ ln productivity (c, j≠i, t-k) + Δ ln productivity (cit)	0.336** (0.099)	0.245* (0.098)	0.104 (0.094)	0.089 (0.093)	0.113 (0.089)

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is measured at the country-industry-year level; aggregate productivity is the country-year level productivity with the own industry netted out. All models estimated with OLS and weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

Table A5e

The effects of industry and aggregate TFP productivity growth on employment growth. Dependent variable: Annual log change in employment by country-industry

	(1)	(2)	(3)	(4)	(5)
Δ ln productivity (cit)	-0.106** (0.014)	-0.105** (0.014)	-0.108** (0.015)	-0.077** (0.012)	-0.076** (0.012)
Δ ln productivity (c, j≠i, t)	0.159* (0.069)	0.177* (0.077)	0.129~ (0.074)	0.094 (0.073)	0.104 (0.072)
Δ ln productivity (c, j≠i, t-1)	0.190** (0.064)	0.213** (0.053)	0.159** (0.050)	0.137** (0.049)	0.147** (0.049)
Δ ln productivity (c, j≠i, t-2)	0.087 (0.063)	0.094~ (0.050)	0.073 (0.047)	0.055 (0.046)	0.067 (0.044)
Δ ln productivity (c, j≠i, t-3)	0.065 (0.055)	0.054 (0.044)	0.061 (0.039)	0.038 (0.038)	0.050 (0.038)
Δ ln total population (ct)	-	-	-	-	1.079** (0.224)
Country fixed effects	*NO*	*YES*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*	*YES*
R2	0.040	0.078	0.114	0.269	0.274
N	12,981	12,981	12,981	12,981	12,981
Σk Δ ln productivity (c, j≠i, t-k)	0.501** (0.095)	0.538** (0.105)	0.422** (0.100)	0.324** (0.097)	0.368** (0.096)
Σk Δ ln productivity (c, j≠i, t-k) + Δ ln productivity (cit)	0.395** (0.092)	0.433** (0.104)	0.314** (0.100)	0.247** (0.098)	0.292** (0.097)

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is value added based TFP is measured at the country-industry-year level; aggregate productivity is the country-year level productivity with the own industry netted out. All models estimated with OLS and weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

Table A6a

The effects of industry and aggregate value-added based productivity growth on domestic consumption growth. Dependent variable: Annual log change in domestic consumption by country-industry

	(1)	(2)	(3)	(4)	(5)
Δ ln productivity (cit)	0.274** (0.048)	0.280** (0.049)	0.262** (0.050)	0.300** (0.052)	0.301** (0.052)
Δ ln productivity (c, j≠i, t)	0.323 (0.288)	0.446 (0.314)	0.023 (0.326)	-0.009 (0.326)	0.006 (0.324)
Δ ln total population (ct)	-	-	-	-	1.025 (1.528)
Country fixed effects	*NO*	*YES*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*	*YES*
R2	0.015	0.033	0.230	0.241	0.241
N	6,838	6,838	6,838	6,838	6,838

Notes: Source: WIOT, 1995-2009. Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is value added based and measured at the country-industry-year level; aggregate productivity is the country-year level productivity with the own industry netted out. All models estimated with OLS and weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

Table A6b

The effects of industry and aggregate based productivity growth on domestic consumption growth, dropping Great Recession years 2008 and 2009. Dependent variable: Annual log change in domestic consumption by country-industry

	(1)	(2)	(3)	(4)	(5)
Δ ln productivity (cit)	0.418** (0.064)	0.413** (0.069)	0.437** (0.062)	0.513** (0.068)	0.512** (0.068)
Δ ln productivity (c, j≠i, t)	-0.313 (0.462)	-0.398 (0.587)	0.136 (0.442)	0.099 (0.440)	0.088 (0.448)
Δ ln total population (ct)	-	-	-	-	0.778 (1.669)
Country fixed effects	*NO*	*YES*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*	*YES*
R2	0.022	0.052	0.278	0.296	0.296
N	5,860	5,860	5,860	5,860	5,860

Table A7a

The effect of industry and aggregate sectoral value-added based productivity growth on employment growth. Dependent variable: Annual log change in employment by country-industry

	(1)	(2)	(3)	(4)	(5)
Mining & utilities & construction					
Δ ln productivity (cit)	-0.307** (0.039)	-0.306** (0.039)	-0.307** (0.038)	-0.301** (0.039)	-0.301** (0.038)
Σk Δ ln productivity (c, j≠i, t-k)	0.014 (0.034)	0.016 (0.032)	-0.003 (0.031)	-0.011 (0.032)	-0.009 (0.032)
Manufacturing					
Δ ln productivity (cit)	-0.098** (0.016)	-0.101** (0.017)	-0.104** (0.017)	-0.117** (0.017)	-0.117** (0.017)
Σk Δ ln productivity (c, j≠i, t-k)	0.191** (0.046)	0.120** (0.044)	0.040 (0.042)	0.049 (0.041)	0.045 (0.038)
Education & health					
Δ ln productivity (cit)	-0.419** (0.037)	-0.417** (0.037)	-0.417** (0.038)	-0.419** (0.038)	-0.418** (0.037)
Σk Δ ln productivity (c, j≠i, t-k)	0.132** (0.043)	0.125** (0.041)	0.133** (0.040)	0.134** (0.039)	0.091* (0.041)
Low-tech services					
Δ ln productivity (cit)	-0.373** (0.041)	-0.372** (0.041)	-0.378** (0.041)	-0.374** (0.042)	-0.373** (0.042)
Σk Δ ln productivity (c, j≠i, t-k)	0.128 (0.078)	0.160* (0.073)	0.151* (0.068)	0.155* (0.068)	0.191** (0.066)
High-tech services					
Δ ln productivity (cit)	-0.282** (0.051)	-0.283** (0.049)	-0.279** (0.049)	-0.242** (0.047)	-0.242** (0.048)
Σk Δ ln productivity (c, j≠i, t-k)	0.115** (0.027)	0.121** (0.030)	0.112** (0.027)	0.086** (0.027)	0.076** (0.023)
Δ ln total population (ct)	-	-	-	-	1.008** (0.193)
Nr of lags in ln productivity (c, j≠i)	*k=3*	*k=3*	*k=3*	*k=3*	*k=3*
Country fixed effects	*NO*	*YES*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*	*YES*
R2	0.251	0.286	0.316	0.343	0.348
N	17,858	17,858	17,858	17,858	17,858

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is measured at the country-industry-year level; aggregate productivity is the sector-year level productivity with the own industry netted out. All models estimated with OLS and weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

Table A7b

The effect of industry and aggregate sectoral productivity growth on employment to working age population. Dependent variable: Annual log change in employment to working age population by country-industry

	(1)	(2)	(3)	(4)
Mining & utilities & construction				
Δ ln productivity (cit)	-0.320** (0.041)	-0.316** (0.042)	-0.323** (0.041)	-0.318** (0.041)
Σk Δ ln productivity (c, j≠i, t-k)	0.031 (0.033)	0.045 (0.032)	0.016 (0.032)	0.007 (0.032)
Manufacturing				
Δ ln productivity (cit)	-0.128** (0.023)	-0.129** (0.023)	-0.132** (0.023)	-0.148** (0.023)
Σk Δ ln productivity (c, j≠i, t-k)	0.174** (0.041)	0.147** (0.044)	0.058 (0.042)	0.068 (0.042)
Education & health				
Δ ln productivity (cit)	-0.359** (0.039)	-0.359** (0.039)	-0.357** (0.040)	-0.360** (0.040)
Σk Δ ln productivity (c, j≠i, t-k)	0.058 (0.039)	0.053 (0.037)	0.073* (0.035)	0.076* (0.035)
Low-tech services				
Δ ln productivity (cit)	-0.348** (0.046)	-0.347** (0.046)	-0.352** (0.046)	-0.347** (0.047)
Σk Δ ln productivity (c, j≠i, t-k)	0.149* (0.062)	0.163* (0.063)	0.149* (0.060)	0.156* (0.060)
High-tech services				
Δ ln productivity (cit)	-0.266** (0.044)	-0.267** (0.043)	-0.267** (0.044)	-0.230** (0.042)
Σk Δ ln productivity (c, j≠i, t-k)	0.111** (0.021)	0.115** (0.026)	0.086 (0.022)	0.058 (0.022)
Nr of lags in ln productivity (c, j≠i)	k=3	k=3	k=3	k=3
Country fixed effects	*NO*	*YES*	*YES*	*YES*
Year fixed effects	*NO*	*NO*	*YES*	*YES*
Industry fixed effects	*NO*	*NO*	*NO*	*YES*
R2	0.240	0.255	0.288	0.317
N	17,858	17,858	17,858	17,858

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is measured at the country-industry-year level; aggregate productivity is the sector-year level productivity with the own industry netted out. All models estimated with OLS and weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

Table A8a

The decadal effects of industry and aggregate sectoral value-added based productivity growth on employment growth. Dependent variable: Annual log change in employment by country-industry

	1970s	1980s	1990s	2000s
All sectors				
Δ ln productivity (cit)	-0.161** (0.048)	-0.295** (0.046)	-0.250** (0.030)	-0.252** (0.026)
Σk Δ ln productivity (c, j≠i, t-k)	0.666** (0.140)	0.332* (0.151)	0.322* (0.127)	-0.003 (0.100)
Σk Δ ln productivity (c, j≠i, t-k) + Δ ln productivity (ict)	0.505** (0.128)	0.037 (0.166)	0.072 (0.124)	-0.255** (0.101)
Mining & utilities & construction				
Δ ln productivity (cit)	-0.189** (0.052)	-0.322** (0.054)	-0.451** (0.090)	-0.269** (0.059)
Σk Δ ln productivity (c, j≠i, t-k)	-0.060 (0.043)	0.072 (0.044)	-0.044 (0.064)	-0.031 (0.048)
Manufacturing				
Δ ln productivity (cit)	-0.040 (0.032)	-0.109** (0.024)	-0.117** (0.025)	-0.201** (0.040)
Σk Δ ln productivity (c, j≠i, t-k)	0.266** (0.074)	0.072 (0.071)	-0.145 (0.101)	-0.038 (0.053)
Education & health				
Δ ln productivity (cit)	-0.327** (0.087)	-0.427** (0.064)	-0.406** (0.071)	-0.530** (0.064)
Σk Δ ln productivity (c, j≠i, t-k)	0.128** (0.049)	0.048 (0.068)	0.236 (0.163)	0.154~ (0.089)
Low-tech services				
Δ ln productivity (cit)	-0.313** (0.070)	-0.477** (0.074)	-0.349** (0.064)	-0.264** (0.026)
Σk Δ ln productivity (c, j≠i, t-k)	0.270** (0.091)	0.109 (0.109)	0.305* (0.120)	0.039 (0.079)
High-tech services				
Δ ln productivity (cit)	-0.167* (0.075)	-0.278** (0.093)	-0.257** (0.052)	-0.307** (0.026)
Σk Δ ln productivity (c, j≠i, t-k)	0.061 (0.039)	0.096* (0.039)	0.213** (0.049)	-0.002 (0.051)
Δ ln total population (ct)	0.948** (0.164)			
Nr of lags in ln productivity (c, j≠i)	*k=3*			
Country fixed effects	*YES*			
Year fixed effects	*YES*			
Industry fixed effects	*YES*			
R2	0.374			
N	17,858			

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is measured at the country-industry-year level; aggregate productivity is the country-year level productivity for the total economy with the own industry netted out. All models estimated with OLS and weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

Table A8b

The decadal effects of industry and aggregate sectoral productivity growth on employment to working age population. Dependent variable: Annual log change in employment to working age population by country-industry

	1970s	1980s	1990s	2000s
All sectors				
Δ ln productivity (cit)	-0.151** (0.047)	-0.323** (0.052)	-0.255** (0.039)	-0.302** (0.033)
Σk Δ ln productivity (c, j≠i, t-k)	0.523** (0.126)	0.173 (0.145)	0.402** (0.116)	0.080 (0.139)
Σk Δ ln productivity (c, j≠i, t-k) + Δ ln productivity (ict)	0.372** (0.114)	-0.150 (0.160)	0.147 (0.110)	-0.222 (0.139)
Mining & utilities & construction				
Δ ln productivity (ict)	-0.184** (0.056)	-0.353** (0.062)	-0.454** (0.092)	-0.296** (0.054)
Σk Δ ln productivity (c, j≠i, t-k)	-0.021 (0.050)	0.059 (0.054)	-0.061 (0.082)	0.065 (0.040)
Manufacturing				
Δ ln productivity (ict)	-0.037 (0.039)	-0.138** (0.031)	-0.155** (0.033)	-0.289** (0.056)
Σk Δ ln productivity (c, j≠i, t-k)	0.210** (0.071)	0.067 (0.084)	-0.021 (0.089)	-0.026 (0.073)
Education & health				
Δ ln productivity (ict)	-0.257** (0.082)	-0.404** (0.060)	-0.305** (0.073)	-0.490** (0.080)
Σk Δ ln productivity (c, j≠i, t-k)	0.095** (0.033)	-0.046 (0.066)	0.214 (0.137)	0.213* (0.085)
Low-tech services				
Δ ln productivity (ict)	-0.270** (0.074)	-0.497** (0.072)	-0.283** (0.075)	-0.271** (0.030)
Σk Δ ln productivity (c, j≠i, t-k)	0.238** (0.076)	0.123 (0.106)	0.219* (0.102)	-0.009 (0.071)
High-tech services				
Δ ln productivity (ict)	-0.147* (0.062)	-0.272** (0.091)	-0.236** (0.047)	-0.285** (0.032)
Σk Δ ln productivity (c, j≠i, t-k)	0.033 (0.032)	0.049 (0.034)	0.201** (0.052)	0.039 (0.046)
Nr of lags in ln productivity (c, j≠i)	*k=3*			
Country fixed effects	*YES*			
Year fixed effects	*YES*			
Industry fixed effects	*YES*			
R2				
N	17,858			

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is measured at the country-industry-year level; aggregate productivity is the country-year level productivity for the total economy with the own industry netted out. All models estimated with OLS and weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

Table A9a

The effect of value-added based productivity growth on employment share by skill type. Dependent variable: Annual change in skill group employment share by country-industry

	High-skilled	Medium-skilled	Low-skilled
		A. OLS	
Δ ln productivity (cit)	-0.002 (0.002)	0.003 (0.003)	-0.001 (0.002)
Country fixed effects	*YES*	*YES*	*YES*
Year fixed effects	*YES*	*YES*	*YES*
Industry fixed effects	*YES*	*YES*	*YES*
R2	0.068	0.154	0.145
N	13,875	13,875	13,875
		B. IV	
Δ ln productivity (cit)	0.026 (0.017)	0.001 (0.023)	-0.027 (0.022)
Country fixed effects	*YES*	*YES*	*YES*
Year fixed effects	*YES*	*YES*	*YES*
Industry fixed effects	*YES*	*YES*	*YES*
Sanderson-Windmeijer F-statistic	37.1	37.1	37.1
N	13,875	13,875	13,875
		First stage for Δ ln productivity	
Mean Δ ln productivity (it) in other countries	0.248*** (0.041)	0.248*** (0.041)	0.248*** (0.041)

Notes: Excludes agriculture, public administration, private households, and extra-territorial organizations. Productivity is value added based and measured at the country-industry-year level. All models weighted by industry employment shares within countries, averaged over the period. The number of observations is equal to the number of country-industry cells multiplied by the number of years. Standard errors are clustered by country-year and reported in parentheses, ~ p<0.10, * p<0.05, ** p<0.01.

Table A9b

High-, medium-, and low-skill employment shares by sector: Five largest countries and fourteen remaining countries

	High-skilled	Medium-skilled	Low-skilled	High-skilled	Medium-skilled	Low-skilled
	1. France			2. Germany		
Mining & utilities & construction	6.6	65.5	28.0	5.4	64.5	30.1
Manufacturing	6.2	56.0	37.8	5.8	61.1	33.1
Education & health	24.6	58.8	16.6	21.0	59.5	19.6
Low-tech services	7.8	60.7	31.5	5.6	65.0	29.3
High-tech services	15.0	68.1	16.9	8.2	68.1	23.7
	3. Japan			4. UK		
Mining & utilities & construction	14.9	59.5	25.6	9.9	71.7	18.4
Manufacturing	14.1	58.9	27.0	6.8	62.3	30.9
Education & health	33.5	60.4	6.1	24.2	55.5	20.3
Low-tech services	16.4	68.2	15.4	8.2	65.0	26.8
High-tech services	26.7	66.1	7.2	15.5	67.8	16.6
	5. USA			6. Mean of all others		
Mining & utilities & construction	18.9	67.8	13.3	9.4	49.8	40.8
Manufacturing	18.2	65.5	16.3	7.5	48.6	43.9
Education & health	48.3	45.8	5.9	37.3	43.7	19.0
Low-tech services	20.2	66.3	13.5	10.6	50.9	38.5
High-tech services	35.7	59.5	4.8	18.6	52.9	28.5

Notes: All shares are for 1992. 6. is the unweighted mean across all 14 remaining countries.

Comment on “Does Productivity Growth Threaten Employment?” by David Autor and Anna Salomons

By Dietmar Harhoff[55]

Abstract

In their contribution to the 4th ECB Forum, David Autor and Anna Salomons provide a very useful analysis of the employment-productivity growth nexus and a decomposition of employment effects in direct and indirect components. This comment revisits the context of the debate as well as their central results and relates them to other recent analyses in labor economics. Since the session also carries “innovation” in the title, this comment proceeds to discuss causes and potential remedies for slow productivity growth in European countries, including the need for revamped educational and innovation policies as a response to digitization.

1 The machine-replaces-human story and its (overly) simple algebra

1.1 A starting point

The fear of wide-ranging substitution of human labor by “machines” is not new – historians have observed that such concerns are an integral part of major waves of innovation (Mokyr et al. 2015). So far, tasks and jobs involving complex combinations of perception and manipulation of artefacts and concepts as well as social and creative intelligence have been mostly exempt from automation. Recent studies have again raised the spectre of far-ranging automation and replacement of human work. Given that, in the past, such concerns were not born out by actual developments, the question has come up: Is this time different? (Furman 2016).

A particularly timely expression of techno-pessimism has been provided by the editors of the British daily The Guardian. In the edition of June 26th[56], the day of the start of this 4th ECB Forum, they discuss the likelihood of particular jobs being

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[56] See https://www.theguardian.com/us-news/2017/jun/26/jobs-future-automation-robots-skills-creative-health. The article essentially draws on results by Frey and Osborne (2013).

replaced by smart machines, artificial intelligence (AI), and internet-based technologies.

The data for this 2017 journalistic assessment come from the study by Frey and Osborne (2017) first published as a discussion paper in 2013. The authors analyze 702 occupations. Frey and Osborne approximate the impact of automation on jobs applying machine-learning techniques. According to the results, some jobs appear reasonably safe: mental health and substance abuse workers (0.3%), occupational therapists (0.35%), and physicians and surgeons (0.42%) face a low risk of automation. Clergy is expected to be automated with a probability of 0.82%. No indication is given to what extent central bankers would be at risk of being replaced by smart bots – but let us expect that they fall on the low-probability end of the scale. Taking the study at face value, others struggle with less rosy predictions: telemarketers (99%), loan officers (98%), cashiers (97%), and paralegal and legal assistants (94%) are described as the “least safe jobs”. Overall, the authors claim that 47% of all employees in the USA work in jobs which could be automated with high probability (>70%). This is an unnerving scenario, and the study has found global attention for exactly this reason.

In the face of such drastic predictions, what makes for reasonably resilient jobs? According to The Guardian (and others), these are characterized by the need for i) genuine creativity (as in design and engineering), ii) building and maintaining complex social relationships (clergy presumably ranks high in this dimension), and iii) working in highly unpredictable environments (as in plumbing).

1.2 More refined approaches

The analysis by Frey and Osborne has been followed by a number of other studies which seek to replicate and extend the approach.[57] Some of these studies try to amend conceptual and methodological weaknesses that may drive the “horror scenarios”. Others give detailed accounts of the new machine capabilities and outline possible implications and policy responses (Brynjolfsson and McAfee 2014). Arntz et al. (2016) criticize the occupation-based approach proposed by Frey and Osborne (2013, 2017) which essentially considers occupations as a whole rather than single job-tasks as the target of automation. Arntz et al. argue that this may lead to an overestimation of jobs at risk. In their assessment, on average 9% of jobs in 21 OECD countries are automatable, with notable differences across OECD countries. For example, Arntz et al. estimate that 6% of jobs in Korea could give way to automation. In Austria, the share of automatable jobs is 12%.These differences between countries may reflect country-level heterogeneity with respect to the organization of work, differences in past investment in automation or differences in educational attainment.

57 See Bonin et al. (2015), Citi GPS (2016), World Economic Forum (2016), Arntz et al. (2016) and McKinsey Global Institute (2017). The latter report provides a detailed survey of these studies.

Even after the decomposition into tasks, studies like the one by Arntz et al. (2016) do not produce reliable estimates regarding the development of total employment. In fairness to the authors of these studies, they do not claim to do that, but reports in the press often follow that interpretation. In particular, the studies discussed and listed before do not take into account: i) effects of enhanced labor demand brought about by reduced prices for goods and services; ii) technologically induced quality improvement effects; iii) complementarities between new technologies and human capabilities which lead to new tasks and jobs; and iv) inter-industry spillover effects of the kind detected below by Autor and Salomons.

2 The contribution by Autor and Salomons

David Autor and Anne Salomons have made ample contributions to the literature on employment and technical change. They have laid some of the groundwork for conceptual developments in measurement and analysis in this field. Early attempts to come to grips with the impact of technology on wages and employment are summarized in Autor and Katz (1999). The theory of skill-biased technological change argues that computer-based technology has become a substitute of simple repetitive tasks and a complement to highly qualified labor. This view has now given way to a more refined perspective of routine-biased technological change in which computers increasingly replace routine tasks mostly found in medium-qualified groups (Autor et al. 2003). The impact on wages has been analyzed in the literature on “job polarization” (Autor and Dorn 2013; Autor et al. 2006; Goos et al. 2009; Goos et al. 2014).

In their contribution to the 4th ECB Forum, the authors tackle four questions: i) Does productivity growth cause advancing industries to grow or shrink (direct effects)?, ii) What is the effect of indirect (cross-industry spillover) effects?, iii) Has the relationship between employment and productivity growth been stable in the past decades?, and iv) What should policymakers worry about: the quantity or quality of jobs? Hence, the analysis for the ECB Forum is not a microscopic study of a particular labor market (as the authors and others have provided before), but a decomposition of employment effects in response to productivity growth. As simple as that may sound, it yields very interesting and useful results.

2.1 Data and basic setup

The authors employ KLEMS data for 24 industries in 19 countries, covering the time period from 1970 to 2007. Leaving aggregate analyses aside for a moment, the data are mostly pooled in country-by-industry-by-year stacked first-difference models, and while some experiments with instrumentation are performed, the authors rely largely on simple OLS estimators. They are upfront about their choices – they are interested in decompositions by industry, time period, and countries, and not in a finely grained study seeking causal inference for a specific question. Moreover, this paper is not a long-term study of employment effects such as Bessen (2017) who follows manufacturing industries over two centuries. Nor do Autor and Salomons consider the sources of productivity gains and employment changes in response to a particular technology (e.g., robotics) such as Acemoglu and Restrepo (2017). The advantage of the authors' approach is that the paper delivers an overview and reliable estimates of cleanly segmented effects. The discussant finds little to quibble with the choices made, given the objective the authors have chosen. In particular, the KLEMS data are a perfectly appropriate choice for this task.

Naturally, the estimates do not consider many aspects that cause heterogeneity – the most important ones being trade (in particular imports from China), off-shoring, institutional setups for education, retraining or redeployment of the workforce, and other forms of labor market policies. These get partially swept into the country, industry, and time period differences and will have to be studied separately. Given the setting of the 4th ECB Forum, some readers may also be in favor of making more use of the time series in the underlying data.

2.2 Main results

In a first step (section 3), the authors show that aggregate employment hasconsistently increased with productivity growth. In OLS regressions with log(number of workers employed) as RHS and changes of log(productivity) as LHS variables, the employment-productivity elasticity is estimated to be about 0.20. This estimate is largely unaffected by including log(population) in the regressions (which has a coefficient of about one) and by employing alternative employment measures such as hours worked, by excluding self-employed individuals or by making adjustments for part-time work. Similarly, the results are robust to using a productivity measure based on value-added instead of output.

The industry-level analysis (sections 4 and 5) reveals that industry employment declines as labor productivity increases – and that it does so robustly across countries and industries, and almost robustly across time periods. Hence, the positive aggregate response of employment to productivity growth is not mirrored at the sectoral level when the industry's own productivity change is used as a regressor. What brings the sectoral results close to the aggregate is the inclusion of productivity changes in other sectors among the regressors. The indirect effects of productivity gains in industries other than the focal one yield a strong positive effect that more than compensates for the employment losses coming via within-industry productivity gains. Autor and Salomons conclude that productivity growth has important spillover effects into other sectors such that the net impact of productivity growth is (weakly) positive. As the most probable sources of indirect effects, they point to income effects (via final demand) and inter-industry demand linkages.

Not surprisingly, the authors find heterogeneous effects across industries – the distribution of productivity growth across sectors matters. The investigation of these differences (section 6) reveals interesting results, among which two stand out: i) manufacturing has the least negative direct effect on employment; and ii) low-tech services have the largest positive spillovers. However, concluding from this result that robotics – when applied in low-tech services – may have strong overall impact on productivity via these spillovers appears to be a rather daring prediction. Which forms of robotics will prevail in services is largely unknown at this point.

2.3 The end of the "virtuous relationship"?

Thus, even after taking sectoral heterogeneity into account, there is a largely positive message. But has the "virtuous relationship" – as the authors call it – been stable over time? The analysis in section 7 shows that there has indeed been some decoupling of employment and productivity growth over the decades. The worst-case scenario unfolds in Table 8 (and Appendix Table 8a) where the authors regress employment on productivity growth in four separate regressions for the respective decades in the dataset. In the last decade, the indirect effects are no longer significant while direct effects of productivity growth on employment remain strongly negative. Proponents of the view that "this time it is different" may take some ammunition from these results. The authors retain their optimism and argue that it is too early to make this call. The results definitely point to considerable fluctuation of the employment-productivity relationship.

2.3.1 Skill-related biases

In their final analysis (section 9), Autor and Salomons return to one of their dominant research topics and consider how employment effects are distributed across different skill groups. Here is where the fortuitous story definitely comes to an end for the low-skilled groups of workers. The authors remind us that labor productivity growth may shift skill demands in two ways – via skill bias to a differential elimination of low-, medium-, or high-skill workers or via a sector bias towards sectors that grow relative to others. The latter effect appears to be particularly important: High productivity growth in manufacturing and primary industries shifts the weight of employment towards more skill-intensive sectors. The record shows that productivity growth has been strongly skill-biased between 1970 and 2007 due to induced sectoral shifts.

Hence, while productivity growth has been good for employment, the skill-related impacts are decidedly non-neutral. The challenge for policymakers is not the quantity of jobs, it lies in the quality of jobs available to low- and medium-skill workers. The redeployment and training of the labor force will continue to be a challenge for policymakers. And it may have a strong geographic component, given the clustering of related industrial activities.

3 The role of educational policies

Autor and Salomons do not discuss educational issues in detail, but I would expect them to agree to the following discussion. Supply and demand for education (and with it the development of educational institutions) have arguably been important determinants of the impact of technological change on the quantity and quality of employment. The relevance of education for mastering technical change at a societal level is not controversial. The argument has been summarized in the recent leader of The Economist (Jan. 14, 2017, p. 9) which – very much in the spirit of Goldin and Katz (2008) – sees inequality as a consequence of education not keeping pace with technological developments.[58] The problem – emphasized by many economists – is that the established organization of learning and education no longer suffices. Lives have become much longer – the once-in-a-lifetime schooling strategy is no longer adequate to adapt skills and knowledge to fast-paced developments. Skill and knowledge acquisition need to be reorganized along the career trajectories. As The Economist puts it, "help all their citizens learn while they earn." But while "lifelong learning" has been on political agendas for a while, so far, there is little in terms of systematic implementation and institutional development. In the realm of education, government policies, institutions, and regulation play a particularly important role. That leaves policymakers with a heavy responsibility. Market forces alone will not suffice to master the adjustment processes. Prudent policy responses are urgently required.

4 Productivity growth and innovation in Europe

While Autor and Salomons take productivity developments as given and focus on their implications for employment, there is another critical issue to which the discussions at the 4th ECB Forum will turn later. Using the leeway that the organizers have given me, I will briefly comment on potential responses to slow productivity growth in European countries, including the need for revamped innovation policies as a response to digitization. As many observers have pointed out, productivity growth in European countries has been lacklustre after the recession of 2007 (OECD 2015a, EFI 2017). This has led some observers to criticize European policies that seek to foster productivity growth and innovation.

It may be instructive for a largely macroeconomics-minded auditorium to take a look at innovation processes "on the ground". The current wave of digitization is not just a challenge to workers, but to large corporates and small- and medium sized firms (SMEs) as well. The "digital transformation" is largely driven by non-European players. Historically successful European corporates have had to assume follower positions with regard to the introduction of data-driven innovations. Even in Europe which was a laggard in this development, start-up firms have emerged as an important type of innovator. Large enterprises have responded by turning to new models of collaboration with start-ups, by setting up accelerators, and engaging in corporate venture capital activities. National innovation policies have turned to these new players as well, by supporting technology transfer from universities and public research organizations and by introducing entrepreneurship in the curricula of aspiring engineers and scientists. Currently, both the practice of innovation management in the private sector and the practice of innovation policymaking are adapting – rather slowly – to new opportunities and challenges.

[58] See Acemoglu and Autor (2012) for a review of Goldin and Katz (2008).

The 2015 OECD report on “The Future of Productivity” holds a number of important lessons and recommendations for policymakers. These should complement the necessary macro-level policies in Europe. They include, inter alia, improvements in the funding and organization of basic research. The report warns against an overly strong emphasis on applied research. In that regard, the formation of the European Research Council (ERC) which has implemented a highly competitive granting mechanism for basic research projects can be seen a clear success at the European level.

The report also calls for global mechanisms to coordinate investment in basic research and for an optimization of policies encouraging research and development activities. In this realm, the preferential tax treatment of intellectual property – e.g., in the form of so-called “patent boxes” – has been a particularly sore point. “Patent boxes” have been shown to be largely beggar-thy-neighbour policies with little positive impact on incentives for innovation (OECD 2015b). Within its BEPS (Base erosion and profit shifting) discussions, OECD working groups have devised the so-called nexus principle which limits tax benefits to income that arises from IP where the actual R&D activity was undertaken by the taxpayer itself. The introduction of this principle is likely to limit the dysfunctional impact of patent boxes.

In the European Union, the consultations for the 9th research framework programme have just begun. This may be an opportunity to learn from past experience by conducting state-of-the-art impact assessments and reducing the bureaucratic components in the support measures offered by the Commission. There is also the looming suspicion that the large number of funding instruments and the complexity of legal arrangements have made grant programs too complex for applicants (EFI 2017).

Coming back to the contribution by David Autor and Anne Salomons: The OECD report “The Future of Productivity” also recommends – very much in their spirit – the reduction of barriers to firm entry and exit and to worker mobility which may stand in the way of labor reallocation. The success of recent labor market reforms, such as in Spain and Germany, lends some weight to this particular recommendation.

5 Conclusions

David Autor and Anna Salomons are to be praised for having provided a solid and reliable foundation for the discussions at the 4th ECB Forum. They have outlined past responses of employment to productivity growth. The authors also discuss important research questions: Wether and how machines can and will substitute or complement human labor is a key aspect in the “new automation” literature. This investigation is related to the quest for explanations for a falling labor share of national income (Elsby et al. 2013, Karabarbounis and Neiman 2014) and for changes in industrial organization, e.g., the emergence of “super-star” firms (Autor et al. 2017). Moreover, Autor and Salomons have emphasized the challenges that policymakers face in supporting the adjustment, redeployment, and training processes required to lessen the negative impact of new technologies. To the discussant, it seems that some European countries have not done badly in this particular dimension over the past waves of automation. But there is an equally important challenge for policymakers: to turn new technological opportunities coming with the internet and digitization into productivity growth. In this dimension, a lot more could and should be achieved in Europe in the coming years.

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Is there an investment gap in advanced economies? If so, why?[59]

By Robin Döttling[60], Germán Gutiérrez[61] and Thomas Philippon[62]

Abstract

We analyze private fixed investment across European economies and in the US over the past 20 years. We study the impact of competition and financial constraints on tangible and intangible investment. We find that investment is weak in both regions, but argue that the reasons are cyclical in Europe and structural in the US. In the US, we find that investment is lower than predicted by fundamentals starting around 2000, and that the gap is driven by industries where competition has decreased over time. The decline in US investment has coincided with increased concentration and decreased anti-trust enforcement. In Europe, we find that investment is roughly in line with measures of profitability and Tobin's Q for the majority of countries, except at the peak of the crisis. Unlike in the US, concentration has been stable or declining in Europe, while product market regulations have decreased and anti-trust regulation has increased. Regarding intangible investment, we find that it accounts for some but not all of the weakness in measured investment. We also find that EU firms have been catching up with their US counterparts in intangible capital. The process of intangible deepening happens mostly within firms in Europe, as opposed to between firms in the US.

1 Introduction

There is widespread agreement that investment, and investment growth, have decreased across Advanced Economies including Europe (see, for example, (IMF, 2014)). The decline in investment has been discussed in policy papers (IMF, 2014; Kose, Ohnsorge, & Ye, 2017), academic research (e.g. Bussiere and Ferrara, 2015) and the media.[63]

There is less agreement, however, on what has caused the decline in investment, whether it is permanent or transitory, and to what extent it can be explained by economic fundamentals. Some authors have emphasized weak aggregate demand

59 We are grateful to Sebnem Kalemli-Ozcan and Carolina Villegas-Sanchez for tremendous help with the Amadeus data, and to Janice Eberly and Philipp Hartmann for comments and discussion. We are also grateful to Benoît Cœuré for chairing our panel.

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62 New York University, CEPR and NBER.

63 See, for example, "Weak Investment Knocks German Economy", *Wall Street Journal*, Nov. 15, 2016; "Lean on me", *The Economist*, March 31, 2016.

as an explanation (Bussiere & Ferrara, 2015), while others have emphasized financial constraints and increased uncertainty (particularly for stressed economies).

This paper aims to differentiate and quantify the contribution of these alternate hypotheses. The main contributions of the paper are to show that: (i) low investment in Europe is largely explained by depressed asset values (Tobin's Q); and (ii) the trends in Europe contrast with those in the US where investment is low despite high levels of Q. As discussed in (Gutiérrez & Philippon, 2016), the difference appears to be explained by rising concentration in the US

We start from the fact that two broad categories of theories can explain low investment rates: theories that predict low investment *because* they predict low Tobin's Q, and theories that predict low investment *despite* high Tobin's Q. The first category includes explanations based on high risk premia or low expected growth. The standard Q-equation holds in these theories, so the only way they can explain low investment is by predicting low values of Q. The second category ranges from credit constraints to oligopolistic competition, and predicts a gap between Q and investment due to differences between average and marginal Q (e.g., market power, growth options) and/or differences between firm value and the manager's objective function (e.g., governance, short-termism).

In Europe, we find that asset values are low and that this explains the majority of the decrease in private fixed investment. In fact, investment relative to Q is not significantly below trend for Europe as a whole, as evidenced by fixed effects in Country- and Industry-level regressions. A wedge appears at the height of the financial and sovereign debt crisis. But it has largely closed since then.

Country and industry-level regressions leave large unexplained residuals, however, and we study several potential explanations. We focus in particular on financial constraints, rising intangible investments, and lack of competition. Testing these theories requires a lot of data, at different levels of aggregation. Some are industry-level theories (e.g., competition), some firm-level theories (e.g., financial constraints), and some theories that can be tested both at the industry- and at the firm-level. We therefore gather country-, industry- and firm-level data. Unfortunately, these data are not readily comparable, because they differ in their definitions of investment and capital, and in their coverage. As a result, we must spend a fair amount of time simply reconciling the various data sources. Much of the work is explained in Section 3 and in the Appendix.

Throughout the paper, we contrast recent investment patterns between the US and Europe. A clear fact emerges: investment in Europe is largely in line with Q while investment in the US is well-below Q. The gap can be explained by rising concentration across a wide range of US industries.

The remainder of this paper is organized as follows. Section 2 briefly discusses the literature. Section 3 discusses our data sample. Section 4 summarizes the empirical evidence on profitability, investment and competition in the US and Europe; and studies the behaviour of investment relative to Q. Section 5 discusses theories that may explain gaps between Q and investment. Section 6 discusses the results of our tests, and section 0 concludes.

2 Related literature

This paper relates to several strands of literature.

First and foremost, our paper adds to the literature documenting the sluggish recovery and associated weak investment in the Eurozone (and the world) since the financial crisis. There is a broad literature on this topic. We simply highlight key references. Most references for Europe highlight a mixture of weak demand, financial frictions and political uncertainty as drivers of weak investment.

(IMF, 2014) discusses weak investment globally and shows that private (business) investment is responsible for most of the investment slump, as opposed to public (or residential) investment. This evidence justifies our focus on business investment. (IMF, 2014) argues that weak demand, financial frictions and political uncertainty are the main drivers of weak investment. Similarly, (Bussiere & Ferrara, 2015) use an augmented accelerator model to show that decreases in expected demand go a long way in explaining the weakness in investment since the Global Financial Crisis. (Lewis & Menkyna, 2014) estimate investment gaps relative to the steady state and find gaps of around 2 percentage points or more in most OECD economies. They again highlight weak demand, financial factors and uncertainty. (ECB, 2016) discusses trends in investment before and after the Great Recession, and finds evidence that credit constraints have declined and investment has increased since 2014. They also highlight the importance of institutional considerations. (Vermeulen, 2016) compares investment in the US and Europe following the Great Recession, and highlights the relatively faster recovery of US investment. (Kose, Ohnsorge, & Ye, 2017) highlight weakness in investment growth in both developing and advanced economies.

Our results confirm the findings of (Kalemli-Ozcan, Laeven, & Moreno, 2015) and (Buca & Vermeulen, 2015), that debt overhang and rollover risk have contributed to weak investment during the Eurozone crisis. Our paper adds to the literature by using Q-theory as the benchmark for investment, by studying differences in trends across asset types – highlighting the effect of rising intangibles – and by focusing on product market competition.

A related literature documenting weak investment in the U.S. includes policy and academic papers. (Furman, 2015) discusses weakness of investment from a policy perspective. (Hall R. E., 2015) shows the capital stock remains below trend. (Alexander & Eberly, 2016) explore firm-level data on investment and document that investment fell relative to fundamentals at the turn of the millennium. They argue that part of the decrease can be explained by changes in industry composition and the rise of intangibles. Closely related, (Gutiérrez & Philippon, 2016) use industry- and firm-level data to test whether under-investment relative to Q is driven by (i) financial frictions, (ii) measurement error (due to the rise of intangibles, globalization, etc),

(iii) decreased competition (due to technology or regulation), or (iv) tightened governance and/or increased short-termism. They find that proxies for competition and ownership explain the bulk of the investment gap, across industries and across firms. Last, (Lee, Shin, & Stulz, 2016) find that industries that receive more funds have a higher industry Q until the mid-1990s, but not since then. The change in the allocation of capital is explained by a decrease in capital expenditures and an increase in stock repurchases by firms in high Q industries since the mid-1990s.

Our paper also relates to the emerging literature that documents rising concentration in the US. The downward trend in business dynamism was highlighted by numerous papers (e.g., (Decker R. , Haltiwanger, Jarmin, & Miranda, 2014)) as early as the mid-2000s, but the trend has been particularly severe in recent years. In fact, (Decker R. A., Haltiwanger, Jarmin, & Miranda, 2015) argue that, whereas in the 1980s and 1990s declining dynamism was observed in selected sectors (notably retail), the decline was observed across all sectors in the 2000s, including the traditionally high-growth information technology sector. Relatedly, (CEA, 2016) discusses a perceived decrease in competition in the goods market. And (Grullon, Larkin, & Michaely, 2016) study changes in industry concentration and its implications for mark-ups. They find that "more than three-fourths of U.S. industries have experienced an increase in concentration levels over the last two decades", which has led to an increase in profit margins and abnormal stock returns. (Autor, Dorn, Katz, Patterson, & Reenen, 2017) link the increase in concentration with the rise of more productive, superstar firms. (Gutiérrez & Philippon, 2016) link the rise in concentration to weak investment; and they establish causality between Competition and investment in (Gutiérrez & Philippon, 2017). (Jones & Philippon, 2016) calibrate a standard macro-economic model assuming that the investment gap is driven by declining competition. They find that the capital stock is 5% to 10% lower than it should be.

This paper adds to the literature by contrasting concentration in Europe to the US. We find that concentration in Europe has not increased, possibly due to relatively more active antitrust enforcement than in the US in recent years. The relative competition hypothesis can explain why investment is roughly in line with Q in Europe while it is significantly below its predicted value in the US. If this hypothesis is correct, it would mark a reversal of the historical pattern where the US has traditionally led the way in fostering competition in goods and services.

Last, our paper relates a growing literature aimed at understanding the growing role of intangible capital and its impact on investment. (Corrado, Hulten, & Sichel, 2009) and (Corrado & Hulten, 2010) are among the early contributions that attempt to measure the intangible capital in US national accounts. Their approach is applied by (Falato, Kadyrzhanova, & Sim, 2013) to measure a stock of firm level intangibles, and has been further refined by (Peters & Taylor, 2016).

(Alexander & Eberly, 2016) and (Döttling, Ladika, & Perotti, 2016) link the rise of intangibles to the decrease in measured investment. (Alexander & Eberly, 2016) study firm-level data with a focus on changes in industry composition. (Döttling, Ladika, & Perotti, 2016) argue that the lower (measured) investment of intangible-intensive firms is related to the way intangible capital is produced. Skilled workers co-invest their human capital, such that firms require lower upfront outlays and external financing. The rising importance of intangible and human capital may therefore be a driver behind some secular trends in the US economy since the 1980s (Döttling & Perotti, 2017).

Our paper contributes to this literature by confirming in European data that industries with a larger share of intangibles appear to invest less. We also compare the process of intangible deepening in Europe vs the US.

3 Data

Testing the above theories requires the use of micro data. We gather and analyze a wide range of country-, industry- and firm-level data. The data fields and data sources are summarized in Table 1. Sections 3.1 and 3.2 discuss the country and industry datasets, respectively. Section 3.3 discusses the firm-level investment and Q datasets; as well as other data sources, including the explanatory variables used to test each theory. We discuss data reconciliation and data validation results where appropriate. Throughout the paper, we restrict results to those periods where available data suffices to reasonably represent the EU economy.

Table 1

Summary of Main Data Sources

Data sources	Data Fields used	Granularity	Coverage	History	Notes
OECD National Accounts	Output (GOS, OS, etc.) from SNA Table 1	Country and sector	~EU28	1976-2015 for most countries	Supplemented with data from Bank of Spain and Bank of Italy
	Balance Sheet (Financial and Non Financial Assets) from SNA Tables 710R and 9B				
	Non-Financial Transactions (Capital Formation, etc.) from SNA Table 14				
OECD STAN	Output (GOS, OS), Capital (K) and investment data (I, NI)	Country and industry	~EU28; ISIC Rev. 4 Level 2	1976-2015 for most countries	Supplemented with KLEMS when missing
KLEMS EU	Output (GOS, OS), Capital (K) and investment data (I, NI)	Country, industry and asset type	10 countries 35 segments based on ISIC Rev. 4 Level 2 10 asset types	Starts between 1970 and 2000 depending on country. Ends on 2014.	
Compustat	Firm-level Financials	Firm-level	All public firms	As early as 1970; good coverage from 1990	Substantial missing data for some fields, even as late as 2005
BVD Amadeus	Firm-level Financials	Firm-level	Public and Private firms	1999-2012 following vintage merging	Substantial missing data for some fields,
Other EU aggregates not used in core analyses	R&D Expenditures from OECD ANBERD	Country and industry	~ ISIC Rev. 4 L2	1998-2013 for most countries	
	Business demographic from OECD SBDS	Country and industry	~ ISIC Rev. 4 L2	2004-2014; many countries only from 2010	
	Business demographic from Eurostat	Country and industry	~ ISIC Rev. 2 L2	2004-2014; many countries only from 2010	

3.1 Country data

Country-level data on funding costs, profitability, investment and market value is gathered from the OECD. We gathered data for the total economy of each country as well as the non-financial corporate sector. The time period of availability varies, but most series start to be widely populated from 1995 onward.

In particular, we source aggregate output data from SNA Table 1, sectoral financial balance sheet data from SNA Table 710R, Non-financial asset data from SNA Table 9B and Non-Financial Transaction data from SNA table 14A. The data appendix summarizes the data series and definitions used.

The quality of non-financial asset data for Italy in the OECD is rather poor, so we source that information directly from the Bank of Italy.[64] Similarly, OECD databases provide incomplete information for the non-financial sector of Spain. We gather that data directly from the Bank of Spain. [65]

We use these data in aggregate and country-level analyses discussed in Section 3 and Section 4.4; in the construction of aggregate Q; and to reconcile and ensure the accuracy of more granular data.

We define the Investment rate as the ratio of Gross fixed capital formation (NFP51P) to lagged Fixed Assets (N11). The depreciation rate as the ratio of Gross fixed capital consumption (NFK1MP) to lagged Fixed Assets; and the net investment rate as the Gross investment rate minus the depreciation rate. Note that we exclude changes in inventories and asset acquisitions from our definition of investment. We also compute the ratio of 'Gross fixed capital formation' to lagged 'Operating surplus and mixed income, gross' (NFB2G_B3GP) and refer to it as I/GOS; and the ratio of net investment ('Gross fixed capital formation' minus 'Gross fixed capital consumption') to net operating surplus ('Operating surplus and mixed income, gross' minus 'Gross fixed capital consumption'). We use current values for all of these calculations because chained values are not available for all countries – most notably Spain.

We also construct our empirical measure of Q using OECD data.[66] Namely, we follow (Hall R. E., 2001) and define

$$Q = \frac{V^e + (L - FA)}{P_k K}$$

where V_e is the market value of equity ('Equity, Liabilities'), L are the value of total liabilities.[67] Note that liabilities are mostly measured at book values, but this is a rather small adjustment, see (Hall R. E., 2001). FA are financial assets (LFAS). For the US, we subtract the value of inventories from the numerator. Data on inventory

64 See http://dati.istat.it/Index.aspx

65 See http://www.bde.es/bde/en/secciones/informes/Publicaciones_an/Central_de_Balan/

66 Calculations for the US are based on FRED data, but are essentially analogous. See the data appendix for additional details.

67 Computed as 'Financial liabilities' (LFLI) minus 'Equity, Liabilities' (LF5LI).

values are not available for Europe so nothing is subtracted. [68] In addition, the value of non-produced assets is missing for several countries in our sample – we estimate these quantities based on the ratio of produced to non-produced assets for those countries that report it. See Section 4.3 and the data appendix for additional discussion.

3.2 Industry data

3.2.1 Investment and Output: OECD industry dataset

Our primary investment dataset is sourced from OECD STAN. OECD STAN is chosen as the basis for our analyses because it provides longer coverage than KLEMS. It also covers a broader set of European economies (essentially all large countries), although we limit most of our analyses to the KLEMS countries. OECD STAN also provides additional industry granularity, which helps us validate our results and the accuracy of other datasets.

STAN includes measures of private fixed assets (current-cost and chained values for the net stock of capital, depreciation and investment) and value added (gross operating surplus, compensation and taxes). It provides breakdowns by country and industry. Data is available as early as 1976 for some countries; though it starts as late as 2000 for others (e.g., Netherlands).

Using these data, we compute the gross investment rate as the ratio of Gross Fixed Capital Formation (GFCF) to lagged net capital stock (CAPN); the depreciation rate as the ratio of Consumption of fixed capital (CFCC) to lagged net capital stock; and the net investment rate as the difference between gross investment rate and the depreciation rate. We use the current replacement cost series for the reported results, but all conclusions are robust to using chained values. We also compute the ratio of Gross Operating Surplus (GOPS) and Net Operating Surplus (NOPS) to lagged capital stock (GOS/K and NOS/K, respectively); as well as the ratio of investment to Gross Operating Surplus and Net Investment to net operating surplus. See data appendix for additional details.

Spain and Great Britain are not covered in the dataset, so we supplement them with KLEMS. Unfortunately, KLEMS provides a less granular industry segmentation than STAN. In order to map across datasets we must first map all STAN industry segments to KLEMS (see the next section and data appendix for details); and then replace the mapped gross investment rate and net investment rate for total gross fixed assets.

68 The above measure aims to isolate the value of productive capital in the numerator and denominator. An alternative measure is the "equity Q", which following (Piketty, 2014) is defined as $Q^{eq} = \frac{V^e}{P_k K + FA - L}$. Both series exhibit very similar trends at the aggregate, though differ in some cases at the country-level. We use the traditional measure of Q in all our analyses.

Similar calculations are performed for the US using data from the BEA; and the US industry segments (which are roughly based on NAICS Level 3 segments) are mapped to ISIC Rev. 4 segments. The mapping is not always perfect, but for most industries the categories are very similar. See data appendix for details.

3.2.2 Investment and Output: KLEMS industry dataset

The main downside of using STAN is that no granularity is available across asset types: data is only available for the total fixed capital. [69]

We therefore use the 2016 release of KLEMS EU to complement STAN. KLEMS EU provides a great level of detail, but is available only over a shorter time period (1995-2014 for most countries; and only after 2001 for Germany). KLEMS also covers only a subset of European economies. Similar to STAN, KLEMS includes measures of private fixed assets (current-cost and chained values for the net stock of capital, depreciation and investment) and value added (gross operating surplus, compensation and taxes). It provides breakdowns by country, industry and asset-type from 1995 onward.

The dataset covers ten countries: Austria, Belgium, Germany, Spain, Finland, France, Great Britain, Italy, Netherlands and Sweden. We group all countries except the non-Eurozone countries Great Britain and Sweden into the ‘EU KLEMS’ grouping throughout the rest of the document, and report series for Great Britain separately where appropriate. Note that only output data is available for Belgium. Belgium is therefore included in the EU KLEMS segment but excluded from regressions based on KLEMS.

Data is available at the sector level (19 groups) following the ISIC Rev. 4 hierarchy. Data for some sectors is further broken out (e.g., manufacturing is split into 11 groups). In principle, this leads to 34 categories; but capital data is not available for some of these groupings (e.g., for Wholesale and Retail trade). We use the most granular segmentation for which data is available, which corresponds to 31 KLEMS categories.

We then exclude Financials to focus on the corporate sector (KLEMS segment K); and Real Estate given its unique experience during the crisis (segment L). We also exclude Utilities (D-E); Public administration and defence (O); activities of households as employers (T); and activities of extraterritorial organizations (U) given the influence of government actions on their investment and the limited coverage of Compustat Global for these industries. This leaves us with 25 industry groupings for our analyses. All other datasets are mapped into these 25 industry groupings.

Capital data fields include nominal and real fixed capital formation by asset type; nominal and real capital stock by asset type; as well as geometric depreciation rates

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69 R&D expenditures are also available from ANBERD but this dataset does not cover all industries, nor accounts for all intangible assets. We therefore use KLEMS for intangibles.

used by KLEMS to compute capital services. Data is available for ten different asset types, which can be grouped into six segments:

- ICT Equipment: Computing equipment, Communications equipment
- Intellectual Property Products: Computer software and databases, Research and development, Other IPP assets (which includes mineral exploration and artistic originals)
- Machinery and Equipment: Transport Equipment, Other Machinery and Equipment
- Cultivated assets
- Residential structures
- Other buildings and Structures

This breakdown allows us to (i) study investment patterns for intellectual property separate from the more 'traditional' definitions of K (structures and equipment); and (ii) better capture total investment in aggregate regressions, as opposed to only capital expenditures.

It is important to note that KLEMS data on gross fixed capital formation, prices, and capital stocks is consistent with Eurostat and the OECD at most industry levels. However, depreciation rates at the more granular asset type-industry level are not part of the official System of National Accounts. Implicit depreciation rates can be derived from official data, but these are often highly volatile. KLEMS therefore reports and applies geometric depreciation rates to compute capital services.

These differences in depreciation rates imply that measures of capital stock from Eurostat are not fully consistent with KLEMS measures of rates of return, rental prices and consequently capital services. Moreover, evolving capital based on the 'net investment rate' implied by the KLEMS depreciation rate does not result in the next period's capital stock. These differences are typically small but can have material implications for some industries as shown in **Chart 2** below.

It is not clear how to address these discrepancies, so we use the KLEMS-implied depreciation rates to compute net investment at the granular asset-type level. Namely, we define country and industry-level gross investment rates as the ratio of 'Nominal gross fixed capital formation' to lagged 'Nominal capital stock'; and net investment rates as the gross investment rate minus the geometric depreciation rate reported by KLEMS. Investment rates are computed for each asset type individually, as well as grouping assets into tangible and intangible assets – in which case we exclude residential structures. When combining asset types, we compute the depreciation rate by applying the KLEMS depreciation rates to the lagged levels of Capital within each country, industry and asset type. We use nominal values of capital and investment, but all results are robust to using chained-quantity indices.

Output data includes gross output, gross value added, compensation of employees and number of employees. We compute the Gross Operating Surplus as the 'Gross value added at current basic prices' minus 'Compensation of employees', and the Net Operating Surplus as the 'Gross Operating Surplus' minus the total depreciation amount by country and industry implied from the capital dataset. OS/K is defined as the 'Net Operating Surplus' over the lagged nominal capital stock.

3.3 Firm-level investment and Q data

3.3.1 Dataset

Firm-level data is used for two purposes: first, we aggregate firm-level data into industry-level metrics and use the aggregated quantities to explain industry-level investment behavior (e.g., by computing industry-level Q and Herfindahls). Second, we use firm-level data to analyze the determinants of firm-level investment through panel regressions (see Section 6 for additional details).

3.3.1.1 Compustat Global

Firm-level data is primarily sourced from Compustat Global – Fundamentals Annual, which is available through WRDS and includes all public firms in Europe. Data is available from 1987 through 2016. However, until the mid-1990s the data quality is relatively poor, and there are many missing values for some key variables. For example, before 1994 CAPX is missing for all firms in Austria and Germany. While we use data from 1990 to compute our variables of interest, these considerations lead us to mostly restrict our firm-level analysis to the years after 1995.

To compute market values, we merge the accounting data with Compustat Global – Security Daily. This dataset contains information about stock prices and outstanding shares for individual stock issues. It is not always obvious how to combine the different stock issues to calculate a company's total market value, and we refer to the appendix for a detailed description of our procedure. To validate our estimates, we compare them to those obtained from the US Compustat-CRSP merged sample whenever possible (i.e., whenever firms are listed in both the US and Europe).

The data is reported in several different currencies. We use exchange rates from the IMF International Financial Statistics to convert all values to Euros.[70]

We exclude firm-year observations with missing assets, or assets under €5 million. Since Tobin's Q and investment are central to our analysis, we also exclude observations with missing Q, negative book or market equity, or strictly negative capital expenditures, R&D or SG&A expenses.

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[70] Before the introduction of the Euro we convert to European Currency Units, the former official monetary unit of the European Union. Some firms still report in national currencies that have been replaced by the Euro (especially in 2000 and 2001). In these cases, we convert using the conversion rate that was fixed when the currency was replaced by the Euro. These conversion rates were obtained from the ECB's website.

Firms are mapped to KLEMS industry segments using ISIC Rev. 4 codes as described in section 3.2 and the data appendix. As above, we exclude utilities; financials; real estate; public administration and defence, compulsory social security; activities of households as employers; and activities of extraterritorial organizations and bodies.

Most of our analysis focuses on firms incorporated in Eurozone KLEMS countries. Our final Eurozone sample has a total of 3,244 firms, of which roughly a third is incorporate in France, and another third in Germany. We repeat some firm-level regressions using the entire sample of EU-28 firms. The final EU-28 sample has a total of 8,052 firms, of which around 2,500 are incorporated in the UK.

For comparisons with the US, we also source data from Compustat North America from 1980-2016. We only keep firms with fiscal incorporation in the US and otherwise apply the same industry-mapping and sampling restrictions as on our European sample.

3.3.1.2 BvD Amadeus and Orbis

Compared to the US, a larger fraction of firms is held privately in European countries. For example, after applying our sampling restrictions, for the period 1995-2016, Compustat covers around 15 times as many US than German firms. In contrast, US GDP in 2016 is only around 5 times that of Germany.

One concern with using public firms is therefore that they do not adequately represent the European economy. While the aggregates computed from Compustat for investment and Q closely follow the industry and country data (see below), we find that this is a larger problem when computing Herfindahls and other measure of competition. For this reason, we also use Bureau van Dijk's Orbis and Amadeus databases, which contain accounting information for private as well as public firms.

There are many problems with these databases, and a long, reliable and representative time series can only be obtained by merging different vintages of the Orbis and Amadeus databases. We are grateful to Sebnem Kalemli-Ozcan and Carolina Villegas-Sanchez for providing us with a historical time series of Herfindahls and Top-firm Market Shares computed based on the merged vintage dataset from (Kalemli-Ozcan, Sorensen, Villegas-Sanchez, Volosovych, & Yesiltas, 2015). We refer to the original paper for details on the sampling and merging procedure.

Herfindahl's and Top firm shares were provided over the 1999 to 2012 period at two levels of granularity: first, at the country-industry level, treating each country as an isolated market; second, at the EU-wide industry-level, treating all countries in the EU KLEMS sample as a single market.

Investment and capital definition

We consider two firm-level investment definitions. First, the 'traditional' gross investment rate is defined as capital expenditures (Compustat item CAPX) at time t scaled by the stock of tangible capital at time t-1, which we measure as net Property, Plant and Equipment (item PPENT). The net investment rate is calculated by imputing the industry-level depreciation rate from KLEMS figures. In particular, note that the depreciation figures available in Compustat include only the portion of depreciation that affects the income statement, and therefore exclude depreciation included as part of Cost of Goods Sold. For consistency, and because we are interested in aggregate quantities, we assume all firms in a given industry have the same depreciation rate, and compute the net investment rate as the gross investment rate minus the KLEMS-implied depreciation rate in each industry.

Second, we estimate investment in intangibles using expenditures on R&D (item XRD) and 20% of SG&A (item XSGA). R&D expenses represent investments in knowledge capital. Adding SG&A accounts for investments in organizational structure (Eisfeldt & Papanikolaou, 2013), and brand equity.

A problem with measuring the stock of intangible capital is that firms do not report the value of most intangible assets on their balance sheet. Instead, accounting rules require firms to expense intangible investments, and deduct them from their earnings.[71] We follow the common approach in the literature to calculate the stock of internally created intangible assets by capitalizing R&D and SG&A spending (e.g. (Peters & Taylor, 2016), (Falato, Kadyrzhanova, & Sim, 2013)).

The procedure uses the perpetual inventory method to capitalize past years' R&D spending. We use R&D depreciation rates from KLEMS, reported to be 20% for all industries. Similarly, we capitalize a portion of 20% of SG&A expenditures, as it includes spending that enhances organizational capital.[72]

Compustat almost always adds R&D expenditures to SG&A. Therefore, we subtract R&D from SG&A, unless R&D exceeds SG&A. We follow the literature and set a depreciation rate of 20% for SG&A.

To calculate the initial stock of internally created intangibles, we divide the first positive, non-missing R&D and SG&A expenditure by the depreciation rate.[73]

A challenge in the European accounting data is that before the adoption of IFRS in 2005, many European firms were reporting in national accounting standards that do not separate out spending on SG&A. This is visible in the data, which has a lot of zero values for SG&A before 2005. We confirmed with S&P that the zeros show up when SG&A is not reported in a national accounting standard. To adequately represent the growth of intangible capital before 2005, we interpolate SG&A spending whenever it shows up as zero, as described in more detail in the Data Appendix. For our investment measure we do not use interpolated values, and

71 Under IFRS firms can capitalize some R&D expenditures. However, as we report in the Data Appendix that seems to only apply to a small fraction of R&D expenditures, warranting our approach to capitalize them under IFRS as well as US GAAP.

72 A weight of 20% on SG&A is the common assumption in the literature, see e.g. (Falato, Kadyrzhanova, & Sim, 2013) and (Döttling, Ladika, & Perotti, 2016).

73 This approach follows (Falato, Kadyrzhanova, & Sim, 2013). A more accurate approach calculates the initial stock of intangibles by imputing intangible investment backward to a firm's founding year (see (Peters & Taylor, 2016)). However, we do not have data on firm founding years.

instead set zero SG&A values to missing. We find that this procedure yields reasonable time series in the aggregate, that compare to investment data from national accounts.

The total stock of intangible assets is defined as the sum of capitalized R&D and SG&A spending, plus balance sheet intangibles (item INTAN) net of goodwill (item GDWL). We subtract goodwill because it includes the market premium for tangible assets. Intangible investment is defined as the sum of R&D and 20% of SG&A at time t, scaled by total intangible assets at t-1.

Total capital is defined as the sum of PPENT and intangible assets. Similarly, total investment is defined as the sum of CAPX and intangible investment at time t, scaled by total capital at t-1.

For comparability, we calculate intangible investment in the US in the same way as in Europe, except that we do not need to interpolate SG&A expenses. US GAAP requires companies to report SG&A throughout our sample period.

3.3.2 Definition of intangible intensity

Part of our analysis focuses on how investment patterns of intangible-intensive firms differ from those of low intangible firms. For that purpose, we define as a firm's intangible ratio the stock of intangible assets divided by its total capital (PPE plus intangibles).

We define as high intangibles (HINT) firms those in the highest tercile of the intangible ratio distribution in a given year, and as low intangibles (LINT) firms those in the lowest tercile.

3.3.3 Q definition

Firm-level stock Q is defined as the book value of total assets (AT) plus the market value of equity (ME) minus the book value of equity scaled by the book value of total assets (AT). The market value of equity (ME) is computed from Secuirty Daily as described in the Data Appendix. The book value of equity is computed as AT - LT – PSTK.

3.3.4 Financial constraints and other firm-level controls

One of our hypotheses is that firms may under-invest because they are financially constrained during the Eurozone crisis. To test this hypothesis, we identify firms that are more adversely affected by the crisis.

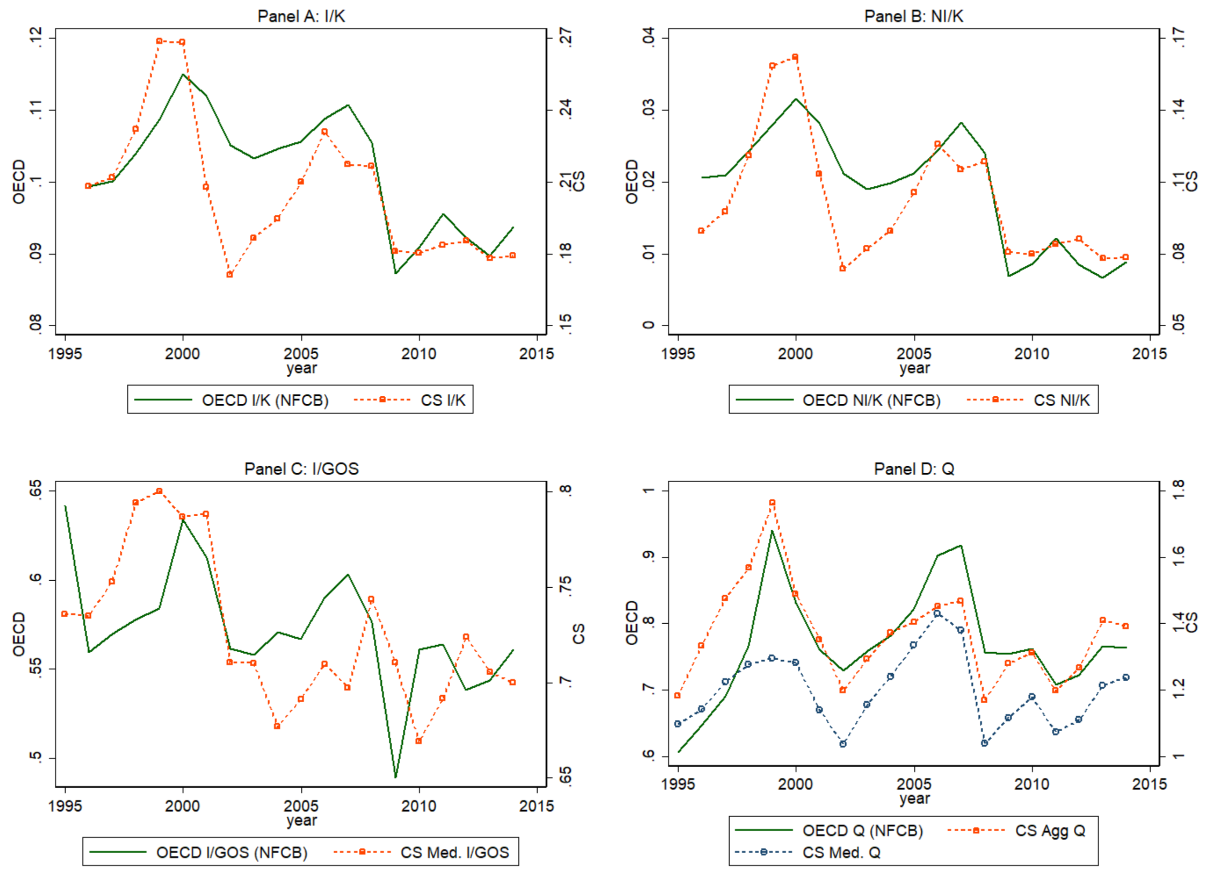
In particular, we calculate a firm's leverage as total debt (sum of items DLTT and DLC), divided by total assets (AT). We also compute a firm's maturity as long term debt (DLTT) divided by total debt. We interact these two measures with dummies for the Eurozone crisis, as described in more detail in section 6. As an additional control, we add firm age, defined as the number of years since a firm entered the sample.

3.4 Data validation

This section summarizes some of the key data reconciliation results across datasets.

Chart 1

Reconciliation of National Accounts and OECD industry datasets



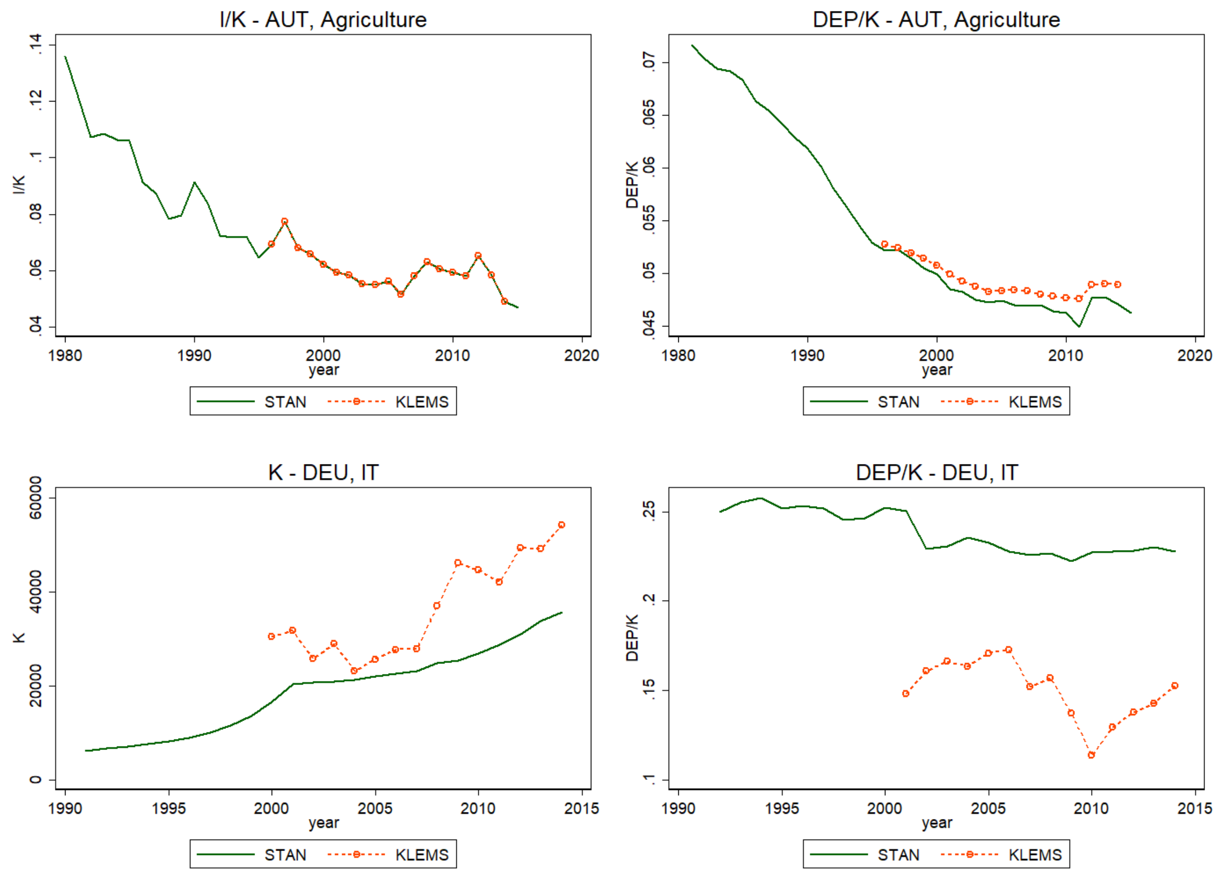
Sources: Annual data for EU KLEMS countries. Data series for Non-Financial Corporate Sector sourced primarily from OECD, except for Spain and Italy for which some of the data is sourced directly from the corresponding central banks (see Section 3 for more details). Capital stock for Italy back-filled from 1996 until 2000 using the mean ratio of NFCB fixed capital to total economy capital based on KLEMS. European series cover all countries from 1996 onward. Compustat series cover the same countries and exclude Utilities, Finance and Real Estate and a few other industries as noted in the text. Either the aggregate (i.e., weighted mean) or median is shown, as noted.
Notes: Figure compares I/K, NI/K, I/GOS and Q for the NFCB sector based on the OECD and across all firms in Compustat Global.

Our primary reconciliation effort relates to firm and aggregate (country / industry) data. **Chart 1** compares I/K, NI/K, I/GOS and Q between the OECD country data for the Non Financial Corporate sector and the aggregate/median computed from our Compustat sample. As shown, the trends between Compustat and the OECD are largely similar across all measures. There are some differences – in terms of levels and trends. Differences in levels are primarily due to differences in definitions of capital between Economic and Accounting measures – where the former are used in National Accounts and lead to larger levels of capital; while the latter tend to depreciate assets 'too quickly' leading lower stocks of capital. Differences in trends are likely due to differences in the behaviour of large public firms and smaller firms; and differences between accounting rules and NSI methodologies. But broadly the patterns are very similar – and suggest the same conclusions.

We also confirm that alternate aggregate sources (i.e., across OECD datasets and between OECD and KLEMS) yield similar time series. **Chart 2** compares STAN and KLEMS data for representative industries to highlight the key issues.

Chart 2

Reconciliation of STAN and KLEMS industry datasets



Sources: Annual data from OECD STAN and KLEMS EU.
Notes: Plots show a comparison of I/K, Dep/K or the level of capital for particular country-industry pairs, as noted in the title of each chart. Top two plots are representative of most time series and show that STAN and KLEMS values almost always align with each other. For some country-industry pairs (most notably information and communication industries), the series differ substantially. This is illustrated in the bottom two plots. The differences are primarily driven by differences in depreciation rates. See text for additional discussion.

The top two charts are representative of most country-industry pairs: the level of capital stock and gross investment is almost always exactly the same across datasets. And the depreciation rate implied by KLEMS geometric depreciation rates is generally very similar from the depreciation rate reported in OECD STAN for all asset types. The KLEMS depreciation rate is typically more stable.

For some country-industry pairs, however, the series differ substantially. This is particularly true for information technology industries, which have a higher share of intangible assets. The bottom two plots highlight these issues focusing on the IT industry for Germany. As shown, the capital stock and depreciation rates can differ substantially in some cases. The differences in capital and investment rates disappear at a higher level of aggregation (i.e., combining all Information and Communication businesses) but they can be material at lower levels of granularity. These issues limit our ability to compare the stock of intangible capital between the US and Europe. We therefore use the share of investment in intangibles as our primary measure of intangible intensity.

4 Business investment in Europe and the US

We present five important facts related to investment in Europe and the US in recent years. We focus on the non-financial sector for three main reasons. First, this sector is the main source of non-residential investment. Second, we can roughly reconcile country and industry data from the OECD with firm-level data from Compustat Global and Amadeus. Third, we can use data on the market value of bonds and stocks for the non-financial corporate sector to disentangle various theories of secular stagnation. And we can use capital and output data from STAN and KLEMS EU for a more granular measure of investment and depreciation across asset types – including intangibles.

For consistency throughout the paper, all results are based on the countries covered by KLEMS, unless otherwise noted. In particular, we refer to the combination of Austria, Belgium, Germany, Spain, Finland, France, Italy and Netherlands as ‘EU KLEMS’. For comparison, we sometimes report time-series for Great Britain. See Section 3 for additional details on our sample. Results are robust to including a broader set of countries.

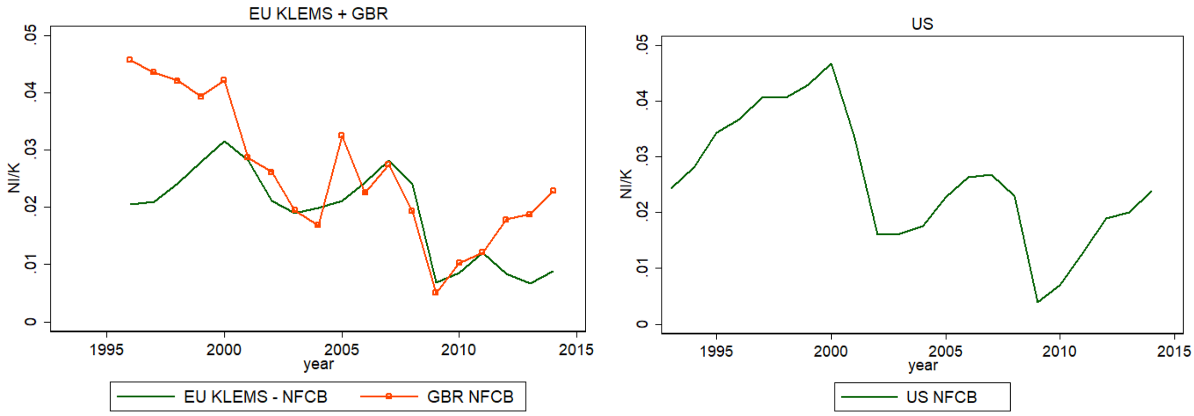
4.1 Fact 1: Investment is Low in the US and Europe

Chart 3 shows the net investment rate by the non-financial corporate sector. The left plot covers Great Britain and the Eurozone; and the right plot covers the US. Note that these series include residential structures as well as intangibles.

As shown, net investment in Europe remained relatively stable from 1995 until the financial crisis, at which point it drops substantially. Depreciation rates (not shown) increase slightly in the early 2000s but decrease after the crisis. As a result, the trend in gross investment is similar to the trend in net investment: it remains flat and drops sharply after the crisis. Net investment in the US rises in the late 1990s with the Dot-Com bubble but drops drastically thereafter. It drops even further with the Great Recession.

Chart 3

Net Investment Rate (NI_t/K_{t-1}) for EU KLEMS and US

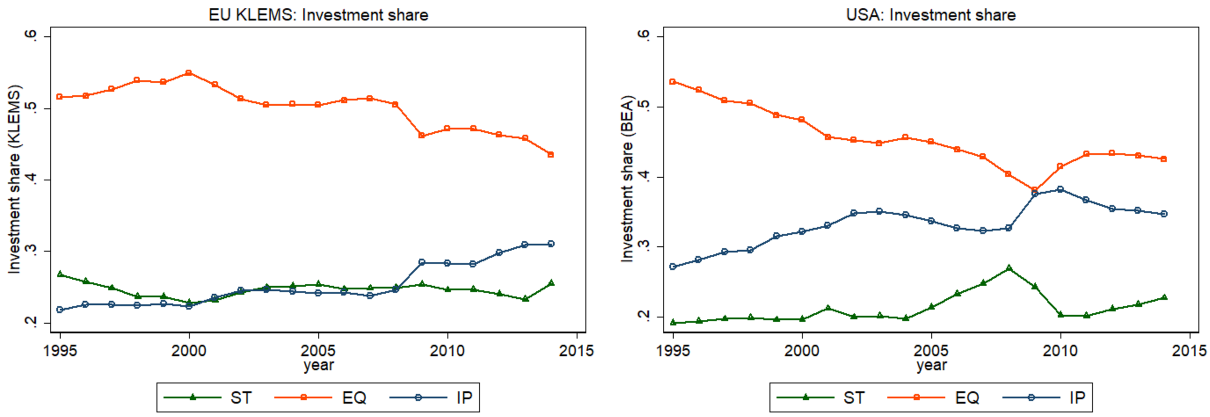


Sources: Annual data for Non-Financial Corporate sector. US data sourced from FRED. Data for European economies sourced primarily from OECD, except for Spain and Italy for which some of the data is sourced directly from the corresponding central banks (see Section 3 for more details). Capital stock for Italy back-filled from 1996 until 2000 using the mean ratio of NFCB fixed capital to total economy capital based on KLEMS. EU KLEMS series covers all countries from 1996 onward except for Finland which starts on 2001.

The composition of investment also exhibits very different trends (see **Chart 4**). In Europe, the share of Equipment decreased consistently since 2000, offset by an increase in the share of Intangible investment. The share of Structures has remained largely stable. By contrast, the share of intangibles in the US increased drastically during the 1990s, but has remained largely stable since the early 2000s. The share of intangibles increases at the height of the Great Recession as corporates cut down on Equipment investment, but returns to the 2003 level by 2015. Despite the rise in Europe, intangibles continue to account for a smaller share of investment in Europe than the US – although this may be in part due to differences in definitions.

Chart 4

Share of Investment by Asset type: EU KLEMS and US



Sources: Annual data from EU KLEMS for Europe and BEA for US. Both series exclude Utilities, Finance and Real Estate. EU KLEMS series includes most countries since 1995 and all countries by 2000.

4.2 Fact 2: Profits are High in US and Low in Europe

Figure **Chart 5** shows the operating return on capital of the non financial corporate sector, defined as net operating surplus over the replacement cost of capital:

$$\text{Net Operating Return} = \frac{P_tY_t - \delta_t P_t^k K_t - W_t N_t - T_t^y}{P_t^k K_t}$$

Chart 5

Net Operating Return (NOS/K) for Non Financial Corporate sector: Europe and US

Sources: Annual data for Non-Financial Corporate sector. US data sourced from FRED. Data for European economies sourced primarily from OECD, except for Spain and Italy for which some of the data is sourced directly from the corresponding central banks (see Section 3 for more details). Capital stock for Italy back-filled from 1996 until 2000 using the mean ratio of NFCB fixed capital to total economy capital based on KLEMS. Eurozone includes all EU KLEMS countries as defined in Section 3, as well as Belgium; and covers all countries from 1996 onward except for Finland which starts on 2001.

As shown, the operating return for European corporates increased in the run-up to the crisis and decreased sharply thereafter. Profit remains substantially lower than pre-crisis levels. By contrast, profits in the US decreased in 2008 and 2009 but have since returned to peak levels, where they remain consistently since 2010.

One may think that investment is low because profits are low. And this is, in fact, part of the story. However, as shown in **Chart 6** it is not the full story. **Chart 6** shows the ratio of gross investment to gross operating surplus; and net investment to net operating surplus for the non financial business sector:

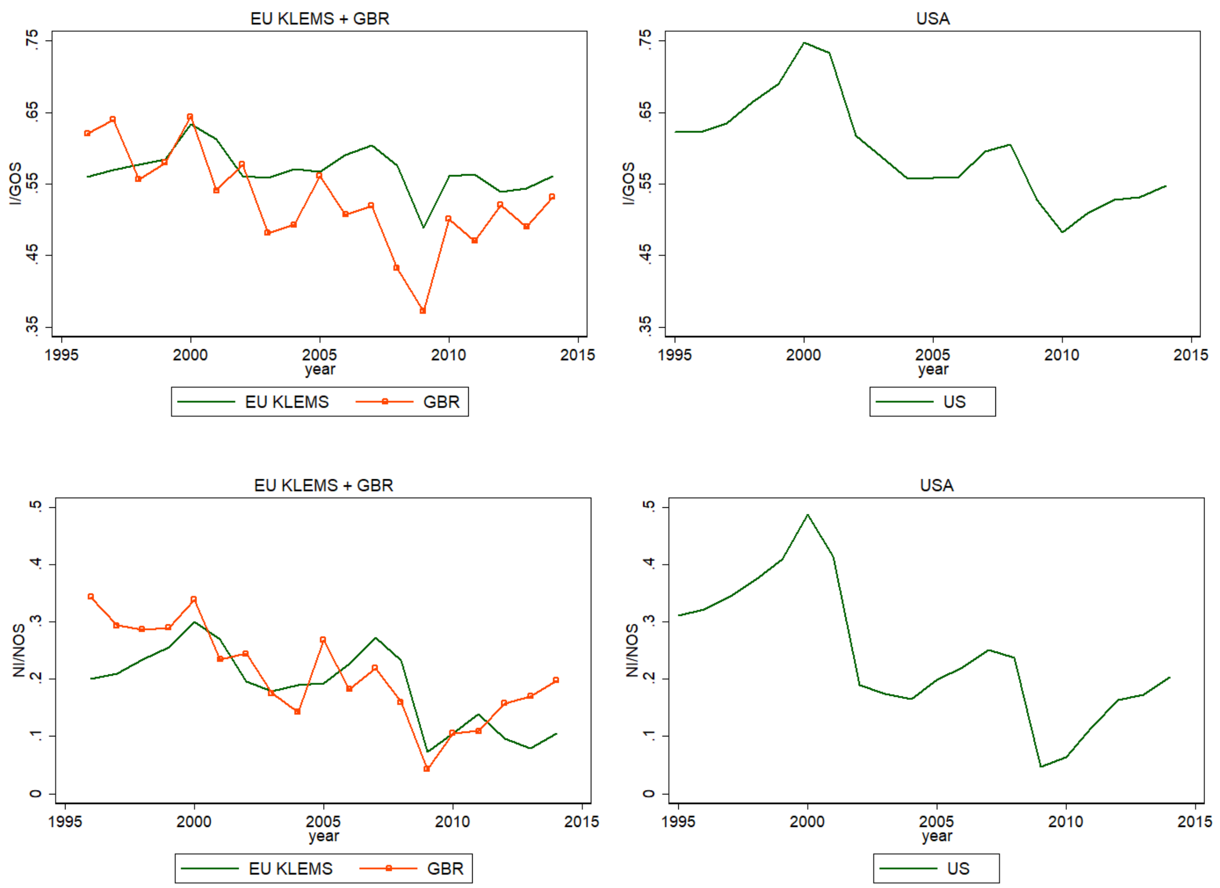
$$\frac{I}{GOS} = \frac{P_t^k I_t}{P_tY_t - W_t N_t - T_t^y}$$

$$\frac{NI}{NOS} = \frac{P_t^k (I_t - \delta_t K_t)}{P_tY_t - \delta_t P_t^k K_t - W_t N_t - T_t^y}$$

As shown, investment relative to operating surplus for European corporates drops in the crisis, but it largely recovers thereafter. By contrast, investment in the US is weak relative to operating surplus, showing that firms do not invest despite high profitability. The ratio of net investment to net operating surplus drops slightly for European corporates, but not nearly as much as for American ones.

Chart 6

Investment Relative to Operating Surplus for Non Financial Corporate sector: Europe and US



Sources: Annual data for Non-Financial Corporate sector. US data sourced from FRED. Data for European economies sourced primarily from OECD, except for Spain and Italy for which some of the data is sourced directly from the corresponding central banks (see Section 3 for more details). Capital stock for Italy back-filled from 1996 until 2000 using the mean ratio of NFCB fixed capital to total economy capital based on KLEMS. EU KLEMS series covers all countries from 1996 onward except for Finland which starts on 2001.

4.3 Fact 3: Q is High in US and Low in Europe

Of course, economic theory does not say that I/GOS should be constant over time. Investment should depend on expected future operating surplus, on the capital stock, and the cost of funding new investment; it should rely on a comparison of expected returns on capital and funding costs. The Q-theory of investment captures this trade-off.

Consider a firm that chooses a sequence of investment to maximize its value. Let K_t be capital available for production at the beginning of period t and let μ_t be the profit margin of the firm. The basic theory assumes perfect competition so the firm takes μ as given. In equilibrium, μ depends on productivity and production costs (wages, etc.). The firm's program is then

$$V_t(K_t) = \max_{I_t} \mu_t P_t K_t - P_t^k I_t - \frac{\gamma}{2} P_t^k K_t \left(\frac{I_t}{K_t} - \delta_t\right)^2 + \mathbb{E}_t[\Lambda_{t+1} V_{t+1}(K_{t+1})]$$

where P_t^k is the price of investment goods. Given our homogeneity assumptions, it is easy to see that the value function is homogeneous in K. We can then define $\mathcal{V}_t = V_t / K_t$ which solves

$$\mathcal{V}_t = \max_x \mu_t P_t - P_t^k (x_t + \delta_t) - \frac{\gamma}{2} P_t^k x^2 + (1 + x) \mathbb{E}_t [\Lambda_{t+1} \mathcal{V}_{t+1}]$$

where $x_t = \frac{I}{K_t} - \delta_t$ is the net investment rate. The first order condition for the net investment rate is

$$x_t = \frac{1}{\gamma}(Q_t - 1)$$

where

$$Q_t \equiv \frac{\mathbb{E}_t[\Lambda_{t+1} \mathcal{V}_{t+1}]}{P_t^k} = \frac{\mathbb{E}_t[\Lambda_{t+1} V_{t+1}]}{P_t^k K_{t+1}}$$

Q is the ex-dividend market value of the firm divided by the replacement cost of its capital stock; and γ controls adjustment costs.

Chart 7 shows the evolution of Q for the non financial corporate sector of EU KLEMS and Great Britain on the left and the US non financial corporate sector on the right. As shown, Q exhibits a highly cyclical pattern in all countries – but the patterns differ drastically in their recovery. Q for EU KLEMS countries remains well below pre-crisis levels; while Q for the US and UK exhibit a strong recovery. For both the US and UK, Q today is at levels last seen in the early 2000s. The recovery aligns with the rise in corporate profits observed for the US and UK but not for EU KLEMS.

Chart 7

Tobin's Q for Non Financial Corporate sector: Europe and US

Sources: Annual data for Non-Financial Corporate sector. US data sourced from FRED. Data for European economies sourced primarily from OECD, except for Spain and Italy for which some of the data is sourced directly from the corresponding central banks (see Section 3 for more details). Capital stock for Italy back-filled from 1996 until 2000 using the mean ratio of NFCB fixed capital to total economy capital based on KLEMS. EU KLEMS series covers all countries from 1996 onward except for Finland which starts on 2001.

It is worth noting that Q for the EU KLEMS countries appears consistently lower than for the UK and US. As pointed out by (Piketty, 2014), lower levels are due to mixture of (i) over-estimation of capital; (ii) under-estimation of equity values; and (iii) differences in control rights valuation across countries.

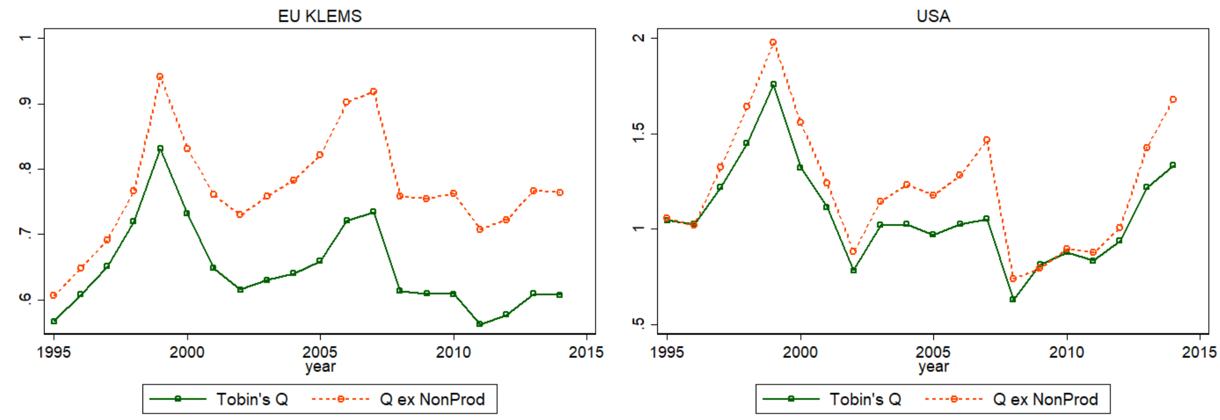
An issue we face constructing these measures of Q is that some countries do not report the value of non-produced assets for the non financial corporate sector (mainly land) while others combine the value of produced and non-produced assets. There are three alternatives: we can include only those countries where non-produced asset values are available; we can exclude non-produced assets from Q; or we can proxy for the value of non-produced assets.

We do not consider the first option because it forces us to exclude several critical countries. Series for the next two are shown in **Chart 8**, where we proxy for missing values of non-produced assets as follows: if a country reports land asset values, we estimate the value of non-produced assets by applying the ratio of non-produced assets to land assets for those countries where data is available. If a country does not report land values, we estimate the value of non-produced assets based on the median ratio of produced and non-produced assets for those countries where data is available.

As shown in **Chart 8** excluding non-produced assets yields a higher measure of Q, which also exhibits an upward trend. We use Q with (estimated) non-produced assets for our core analyses; but note that our results are robust to excluding non-produced assets in Q so long as we control for the trend. Importantly, these measures of Q are largely consistent with those observed from firm-level data (see Section 3 for additional details).

Chart 8

Tobin's Q including and excluding Non-produced assets for Non-Financial Corporate sector: EU KLEMS and US



Sources: Annual data for Non-Financial Corporate sector. US data sourced from FRED. Data for European economies sourced primarily from OECD, except for Spain and Italy for which some of the data is sourced directly from the corresponding central banks (see Section 3 for more details). Capital stock for Italy back-filled from 1996 until 2000 using the mean ratio of NFCB fixed capital to total economy capital based on KLEMS. EU KLEMS series covers all countries from 1996 onward except for Finland which starts on 2001. Where noted, capital stock excludes non-produced assets (mainly land) for all countries except the UK and Italy. For the US, we exclude the value of land only since non-land non-produced assets are not available.

4.4 Fact 4: Concentration has been stable in Europe and rising in the US

Chart 9 plots mean sales Herfindahls for the EU and the US. (Gutiérrez & Philippon, 2016) show that low investment in the US is associated with rising concentration.

The increase in concentration in the US is evident in the average Herfindahl, which has been trending upward since the early 2000s. The increase is even more pronounced when controlling for common ownership.

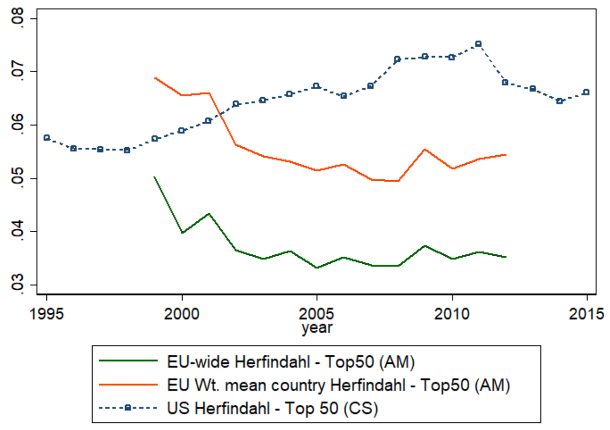
For the EU, Herfindahls are displayed both on an EU-wide level, treating the European Union as a single market, as well as on a country level, assuming nationally segmented markets. While we are not able to compute EU Herfindahls before 1999, they have been stable or decreasing since the beginning of our sample. The mean country-level Herfindahl is comparable to the US – at least in the first years of our sample. On an EU-wide level, concentration is (mechanically) lower.

A similar picture emerges looking at the market share of the largest companies in the EU. **Chart 10** plots the fraction of sales by the largest 4 and respectively 50 companies, on an EU-wide and country-level basis. As above, the share of the top 4 firms has been stable or decreased, either when considering the EU as a single market or taking weighted averages across countries.

Two more observations are in order. First, note that the increased integration among EU economies essentially shifts the appropriate measure of concentration from the red line towards the green one – which further strengthens the trend. Second, the differences in concentration trends suggest that factors other than economies of scale/network effects are at play, since these would presumably have similar effects in both regions.

Chart 9

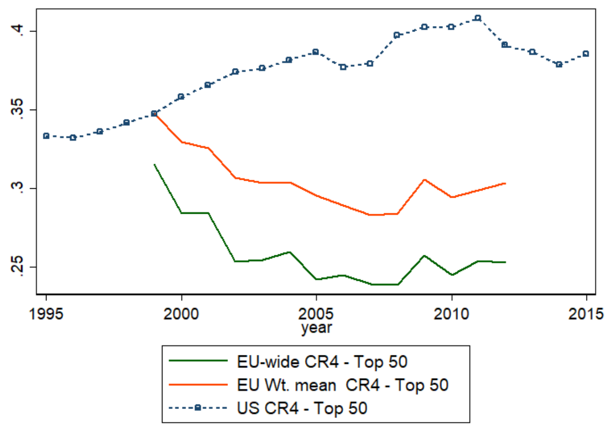
Herfindahls: EU and US



Sources: European values based on Herfindahls and sales provided by Sebnem Kalemli-Ozcan and Carolina Villegas-Sanchez. They are based on the dataset constructed for (Kalemli-Ozcan, Sorensen, Villegas-Sanchez, Volosovych, & Yesiltas, 2015). US Herfindahls from Compustat.
Notes: EU-wide Herfindahl is computed treating the EU KLEMS countries as a single market. Country Herfindahls treat European countries as separate markets, and compute the EU average weighting by aggregate sales in a given industry. The US Herfindahl is computed using Compustat. All Herfindahls are computed based on the top 50 companies in terms of sales in a given industry.

Chart 10

Top 4 firm market share: EU and US



Sources: European values based on data provided by Sebnem Kalemli-Ozcan and Carolina Villegas-Sanchez. They are based on the dataset constructed for (Kalemli-Ozcan, Sorensen, Villegas-Sanchez, Volosovych, & Yesiltas, 2015). US Herfindahls from Compustat.
Notes: EU-wide market shares are computed treating the EU as a single market. Country-level market shares treat European countries as separate markets, and compute the EU average weighting by aggregate sales in a given industry. The US measure is computed using Compustat. All concentration ratios are computed based on the top 50 companies in terms of sales in a given industry.

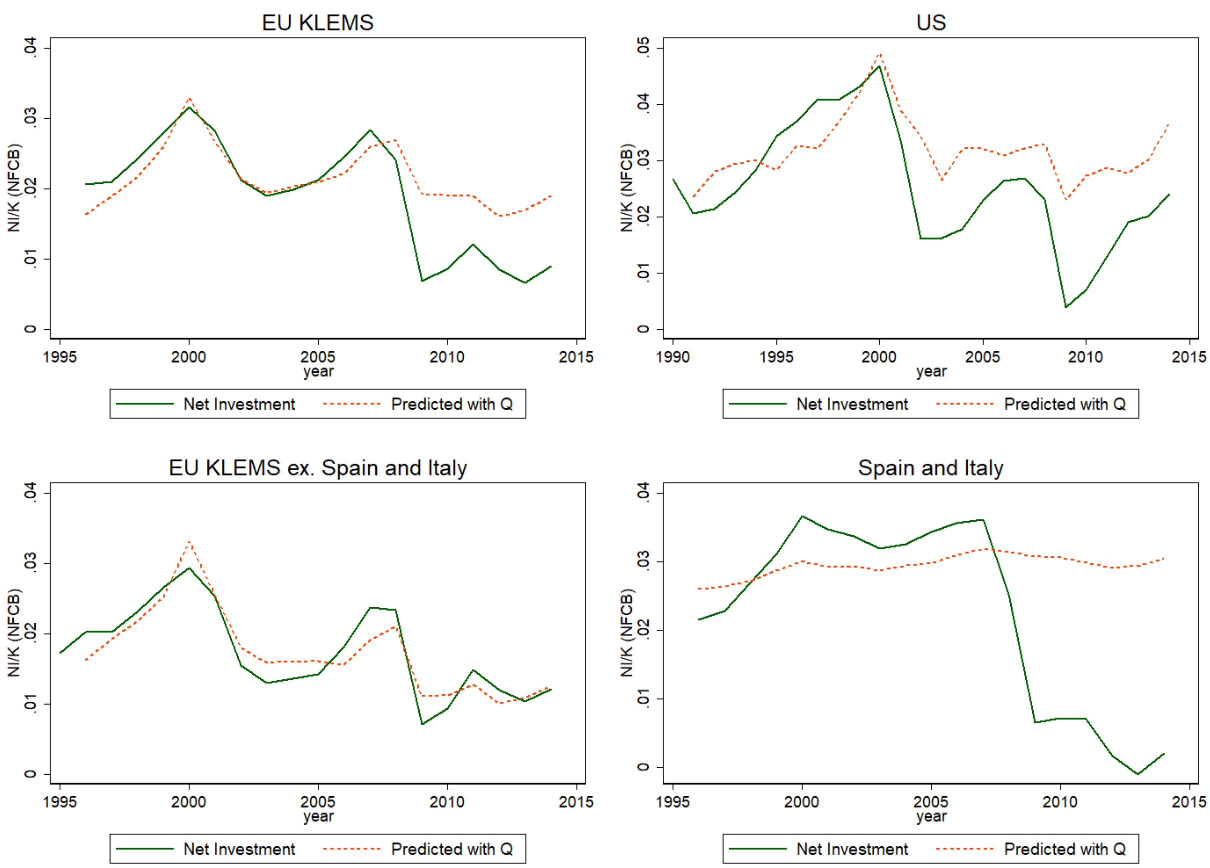
4.5 Fact 5: Investment is on-par with Q in most of Europe yet below Q in the US

Chart 6 above shows that investment has decreased for both Europe and the US, while **Chart 7** shows that Q remains depressed for Europe yet is high for the US.

Taken together, these facts suggest that investment in Europe is largely in-line with Q, while it is well-below Q for the US. We confirm this conclusion by estimating time series regressions of net investment on Q, as shown in **Chart 11**. The top-left plot shows the actual and predicted net investment rate for the EU KLEMS sample based on a time series regression of net investment on Q from 1996 to 2009.

Chart 11

Actual and Predicted Net investment for Non-Financial Corporate Sector: EU KLEMS and US



Sources: Annual data for Non-Financial Corporate sector. US data sourced from FRED. Data for European economies sourced primarily from OECD, except for Spain and Italy for which some of the data is sourced directly from the corresponding central banks (see Section 3 for more details).
Notes: Figure shows the actual and predicted net investment rate by for Non-Financial Corporate sector. Predicted series based on a regression of net investment on lagged Q from 1996 to 2009 for Europe and 1990 to 2001 for the US.

Based only on this plot, a gap between Q and investment appears starting on 2009. The bottom two charts separate Spain and Italy from the rest of EU KLEMS countries and show that the gap is concentrated in the former two countries – which were most heavily hit by the Great Recession and Eurozone crisis. Combining the rest of EU KLEMS countries we find no investment gap – some of these countries exhibit a small investment gap (Germany and Belgium) while others exhibit some over-investment (Netherlands). But on the whole investment appears largely aligned with Q for these countries.

The top-right plot shows the same result for the US, except the regression is based on 1990 to 2001 (given the longer sample available and the presence of a gap as early as 2000 – see (Gutiérrez & Philippon, 2016) for additional discussion). As shown, investment has remained well below Q since 2000.

We confirm these conclusions by studying the time effects of more granular regressions (at the industry and country-industry level) of net investment on Q. See **Chart 12** in Section 6.1 for sample results for Europe.

5 What might explain deviations from Q?

The above results highlight the presence of a gap between investment and Q for some countries. We therefore study theories that may explain deviations between investment and Q.

The basic Q-equation (1) says that Q should be a sufficient statistic for investment, while equation (2) equates Q with the average market to book value. This theory is based on the following assumptions (Hayashi, 1982):

- no financial constraints;
- shareholder value maximization;
- constant returns to scale and perfect competition.

Deviations between investment and Q could be explained by a variety of theories – we consider the following three:

1. **Financial frictions:** A large literature has argued that frictions in financial markets can constrain investment decisions and force firms to rely on internal funds. See (Fazzari, Hubbard, & Petersen, 1987), (Gomes, 2001) (Moyen, 2004) (Hennessy & Whited, 2007) and (Hennessy & Whited, 2007). There is considerable controversy about the implications of financial frictions, of course, but this does not matter for our analysis because we are not interested in estimating elasticities. While financial frictions make internal funds relevant, it is not at all clear that they increase the sensitivity of investment to cash flows. (Kaplan & Zingales, 1997) and (Gomes, 2001) show that financial frictions might not decrease the fit of the Q equation much. (Kaplan & Zingales, 1997) show that industrial sectors that are relatively more in need of external financing develop disproportionately faster in countries with more developed financial markets. In the end, if certain sectors depend on external finance to invest and are unable to obtain the required funds, they may under-invest relative to Q.
2. **Intangibles:** The rise of intangibles may affect investment in several ways: first, intangible investment is difficult to measure and is therefore prone to measurement error. Under-estimation of I would lead to under-estimation of K,

and therefore over-estimation of Q; and would translate to an observed under-investment at industries with a higher share of intangibles. Moreover, the creation of intangible capital relies more heavily on the co-investment of high-skill human capital (Döttling, Ladika, & Perotti, 2016). This may be a factor contributing to low measured investment at intangible-intensive firms, as effort exerted by employees is typically not counted as firm investment. Alternatively, intangible assets might be more difficult to accumulate. A rise in the relative importance of intangibles could then lead to a higher equilibrium value of Q even if intangibles are correctly measured.[74]

3. **Competition:**

   (a) **Regulations & uncertainty**: Regulation and regulatory uncertainty may affect investment in two ways. First, increased regulation may stifle competition by raising barriers to entry. This can create a gap between Q and investment. Second, irreversible investment in an industry may decline if economic agents are uncertain about future payoffs (see, for example, (Bernanke, 1983; Dixit & Pindyck, 1994)). Note, however, that policy uncertainty regarding future cash flows should be priced in Tobin's Q.

   (b) **Concentration:** A large literature has studied the link between competition, investment, and innovation (see (Aghion, Howitt, & Prantl, 2014) for a discussion). From a theoretical perspective, we know that the relationship is non-monotonic because of a trade-off between average and marginal profits. For a large set of parameters, however, we can expect competition to increase innovation and investment. Firms in concentrated industries, aging industries and/or incumbents that do not face the threat of entry might have weak incentives to invest.

6 Results

Armed with the requisite country-, industry- and firm-level data, we can analyze the determinants of country-, industry and firm-level investment. Throughout this section, we label firms with i, industries with j and countries with c.

We start by showing regression results at the country-industry-level, which allow us test for the impact of competition, intangibles and, to a lesser extent, financial constraints. Next, we report firm-level regression results. The latter allow us to test for the effect of intangibles and financial constraints.

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74 Intangibles can also interact with information technology and competition. For instance, Amazon does not need to open new stores to serve new customers; it simply needs to expand its distribution network. This may lead to a lower equilibrium level of tangible capital (e.g., structures and equipment), thus a lower investment level on tangible assets. But this would still be consistent with Q theory since the Q of the incumbent would fall. On the other hand, Amazon should increase its investments in intangible assets. Whether the Q of Amazon remains large then depends mostly on competition. Finally, intangible assets can be used as a barrier to entry. For all these reasons, we think that it is important to consider intangible investment together with competition.

6.1 Country-Industry results

Chart 11 shows that European investment has remained largely in-line with Q. In this section, we further test this hypothesis by studying investment at the country-industry level. This also allows us to test for the effect of alternate hypotheses (financial constraints and intangibles) on investment.

In particular, we run the following panel regression:[75]

$$\frac{NI_{j,c,t}}{K_{j,c,t-1}} = \beta_0 + Q_{j,c,t-1}\beta_{1,j,c} + X_{j,c,t-1}\gamma_{j,c} + \mu_c + \alpha_i + \eta_t + \varepsilon_{i,t}$$

where, β_0, μ_c, α_j and η_t represent a constant, country fixed effects, industry fixed effects, and year fixed effects, respectively. $X_{j,c,t-1}$ denotes variables we include to test our hypotheses, including financial constraints, and intangible ratios; as well as industry-level controls. Country fixed effects control for stable heterogenous variation across countries such as long term growth rates; as well as data issues disproportionately affecting some countries (see data appendix for discussion). Industry fixed effects control for differences in average investment and adjustment costs across industries. Last, time fixed effects are included because our identification strategy relies on the cross-section. We control for average firm age in all regressions.

Table 2 shows the results of these regressions. Columns (1) to (5) are based on STAN investment rates; while columns (6) to (8) are based on KLEMS to separate across asset types.

For all regressions, we test whether country-industry level or EU-wide industry-level predictors exhibit stronger significance. EU-wide Q and Intangibles work better; while for Herfindahls the country-level measures works better. This suggests a greater integration of asset markets than of product markets. That said, the significance of EU-wide Q is not primarily due to recent years: it is a more robust predictor over virtually all historical periods for which data is available. This is consistent with short term volatility in country-level premia that firms with long horizon might discount.[76]

75 Results using log-Q are similar to those using Q directly.

76 Note that we do not use XTREG because this is not a “true” panel: observations across countries are highly correlated. We use AREG and confirm that coefficients are significant with alternate treatments of standard errors.

Table 2
Net Investment by Industry and Country

	All Fixed assets						Tangible	Intangible
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Time period	1995-2014	1999-2012	1995-2014	1999-2012	1999-2012	1999-2012	1999-2012	1999-2012
Data source	STAN	STAN	STAN	STAN	STAN	KLEMS	KLEMS	KLEMS
Median $Q_{j,t-1}$ (CS)	**0.020**** [7.37]	**0.017**** [4.45]	**0.018**** [6.39]	**0.015**** [3.95]	**0.015**** [3.94]	**0.011+** [1.94]	**0.016**** [3.23]	
Median $Q_{c,j,t-1}$ (CS)								**0.011*** [2.80]
$Herfindahl_{c,j,t-1}$ (AM)		**-0.037**** [-5.61]		**-0.037**** [-5.42]	**-0.035**** [-5.06]	**-0.044**** [-4.02]	**-0.042**** [-4.28]	-0.03 [-1.03]
$Intangible\ inv.share_{j,t-1}$ (KL)			**-0.121**** [-3.75]	**-0.125**** [-3.42]	**-0.119**** [-3.24]	**-0.088*** [-2.59]	**-0.111**** [-3.17]	-0.173 [-1.20]
Mean $Leverage_{c,j,t-1}$ (CS)					0.014 [1.19]	-0.016 [-1.39]	-0.011 [-0.99]	-0.009 [-0.33]
Recession dummy					-0.012+ [-2.03]	-0.013* [-2.74]	-0.021** [-3.46]	0.036* [2.66]
Mean $Leverage_{c,j,t-1}(CS) \times$ Recession					**-0.043**** [-3.12]	**-0.040*** [-2.50]	**-0.043*** [-2.26]	-0.05 [-1.23]
Mean $Maturity_{c,j,t-1}$ (CS)					-0.002 [-0.35]	-0.001 [-0.17]	-0.005 [-0.80]	0.014 [1.37]
Mean $Maturity_{c,j,t-1}(CS) \times$ Recession					**0.02** [1.61]	**0.016+** [1.90]	**0.025**** [2.92]	-0.033 [-1.41]
Intangible Gap '01 (KL and BEA)								**0.162**** [4.54]
Mean $LogAge_{c,j,t-1}$ (CS)	-0.014 [-1.44]	-0.026* [-2.53]	-0.012 [-1.37]	-0.022* [-2.27]	-0.022* [-2.55]	-0.015+ [-1.85]	-0.013 [-1.47]	-0.060* [-2.43]
Observations	3,616	2,650	3,616	2,650	2,650	2,290	2,290	2,290
R^2	0.388	0.403	0.394	0.407	0.416	0.486	0.43	0.454
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Sources: Authors calculations based on annual data from OECD STAN, EU KLEMS, Amadeus and Compustat Global. Herfindahl's provided by Kalemli-Ozcan and Villegas-Sanchez
Notes: Table shows results of regressions of Net investment at the country-industry level on Q, along with alternate regressors. All regressions include a control for the average age of firms in a given industry. Column 1 includes only median Q across all firms in Compustat for a given industry. Column 2 adds the Herfindahl computed based on Amadeus for a given country-industry pair over the 1999-2012 period. Column 4 includes the share of investment in intangible assets for a given industry, computed based on KLEMS. Column 3 includes both the Herfindahl and Intangible investment share. Column 5 adds two measures of financial constraints (leverage and maturity) interacted with a recession dummy defined for each country. Column 6 shifts to KLEMS data. Results are fairly stable although the coefficient on Q is lower. Column 7 focuses on tangible assets and shows that financial constraints disproportionately affect these types of assets. Column 8 focuses on intangible investment and adds the gap between the share of intangible assets in the US and Europe as of 2001 as a predictor. It shows that (i) financial constraints have a lower effect on intangible assets and (ii) that industries with a larger investment gap invested more on intangible assets relative to Q. T-stats in brackets. Standard errors clustered at the industry level. + p<0.10, * p<0.05, ** p<.01.

The results show the stability of coefficients on Q across regressions and asset types. We emphasize the following points:

- Col 1: the coefficients are similar to those obtained for the US by (Gutiérrez & Philippon, 2016).
- Col 2: adds the Herfindahl, which exhibits a negative coefficient.
- Col 3: adds the industry-average share of investment in intangible assets. If a decrease in firm investment needs driven by the rise of intangibles explains low investment, the coefficient on intangibles ratio should be negative and significant – as observed.

- Col 4: combines Herfindahl and industry-average intangibles and finds that both are robust predictors of investment.
- Col 5: adds measures of financial constraints interacted with a recession dummy. This dummy takes the value 1 if a country is officially in a recession at any point in a given year. Industries with higher leverage and more short term debt cut investment more during recessions.
- Col 6-8 are based on KLEMS to separate tangible and intangible assets. These data are noisier. The coefficients are similar in magnitudes but not significant in some cases – likely due to noise in measurement and depreciation.

In Column 8 we test the idea that the EU is catching up with the US in intangible investment. To do so we introduce the intangible investment gap, defined as the gap between the share of intangible assets in the US and Europe as of 2001. The intangible gap with the US is a strongly significant predictor of more intangible investment in Europe, consistent with the catching up hypothesis.

Our benchmark for investment is the Q-equation. To assess whether our hypotheses can explain the investment gap, **Chart 12** shows the time-series of time effects from country-industry regressions on Q. We include the mean time-effect over the regression period for comparison. Note that net investment (the dependent variable of the regression) is not de-meaned so average time effect need not be zero.

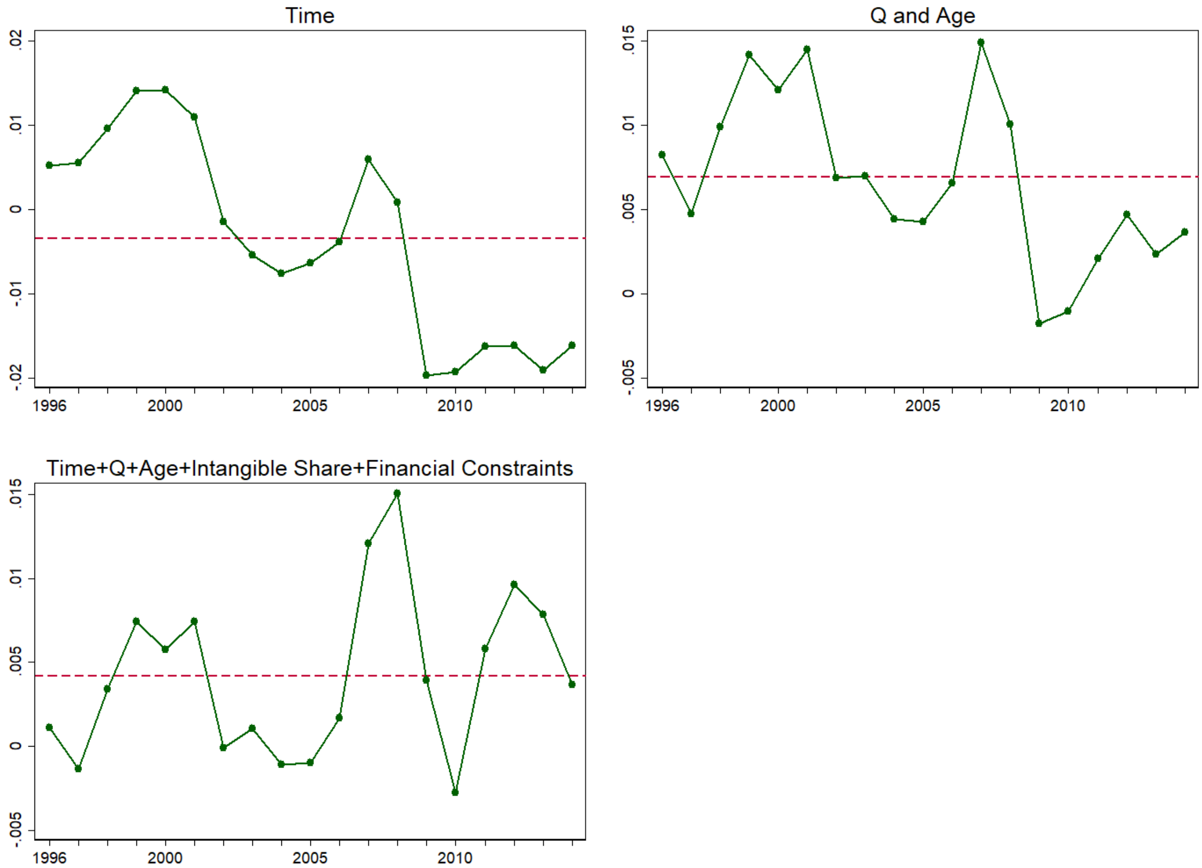
The top left plot includes only industry, country and time fixed effects, and shows that investment decreased after 2000. The top right plot adds Q and Age to the regression and shows that these two variables explain the majority of underinvestment; but a drop remains. This regression corresponds to column 1 above.

The Bottom left plot adds the intangible share of investment and financial constraints and shows that time effects no longer exhibit a clear trend or sustained drop after the crisis. Our explanatory variables, therefore, appear to explain the drop in investment.[77]

[77] Similar results are obtained separating asset types or considering EU-wide industry level regressions; but are not reported for brevity.

Chart 12

Time effects of Country-Industry regressions, by predictor variables included



Sources: Annual data. Aggregate data sourced from BEA for US and KLEMS for Europe. Exclude Finance, Real Estate and Utilities. Compustat data from Compustat Global for Europe and Compustat NA for US.

6.1.1 Concentration: detailed discussion

The results in **Table 2** highlight the effect of concentration on investment; and section 4.4 notes the differences in trends between the US and Europe. In Europe, we see weakly decreasing concentration and this has a limited impact on investment. On the other hand, concentration is rising in US and this has a fairly large effect on investment, as argued in (Gutiérrez & Philippon, 2017).

To further highlight the differences between Europe and the US, **Chart 13** studies investment patterns at the top 5 concentrating industries in the US (excluding Textiles for which concentration does not reflect decreasing competition but rather increasing *foreign* competition). The series are aggregated across industries based on the US share of sales for Herfindahl and US share of capital for I/K to ensure a common weighting of industries.[78]

Chart 13

Comparison of concentration and investment at Top 5 concentrating industries in US

Sources: Authors calculations based on annual data from OECD STAN, Amadeus and Compustat.
Notes: Figure based on the top 5 concentrating industries in the US after excluding Manufacturing – Textiles which is heavily affected by Chinese competition (results are similar including Manufacturing - Textiles). These industries include Information Telecom, Arts and Recreation, Wholesale and Retail trade, Other Services and Information Publishing. First chart shows the weighted average Herfindahl across these industries, weighted by sale. The second chart shows the weighted average investment rate, weighted by capital stock, As shown, concentration increased drastically in the US while decreased for Europe. Investment in Europe appears relatively stable – especially compared to the US where it decreases drastically.

We find that, in these industries, investment has decreased much more in the US than in Europe, despite rising profits in the US and dropping profits in Europe. The differences in investment also appear when controlling for Q through regressions. They are, therefore, likely due to decreased competition.

As noted above, since economies of scale/network effects presumably would have similar effects in both regions, the differences in concentration trends suggest that other factors are at play. This begs the question of what may explain the rise in concentration in the US? (Grullon, Larkin, & Michaely, 2016) and (Gutiérrez & Philippon, 2017) argue that reduced anti-trust enforcement and increased regulation have played a role, respectively.

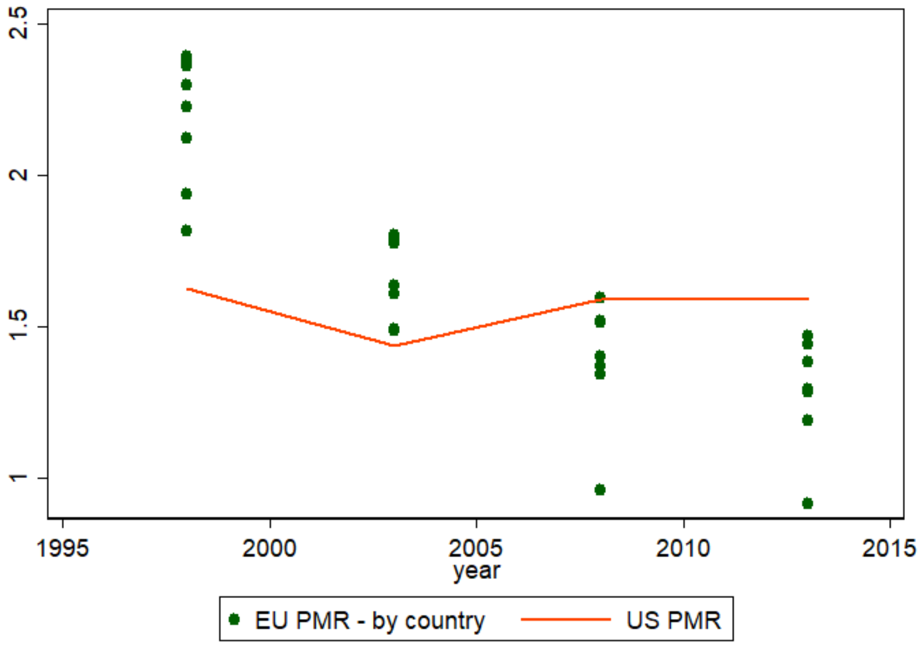
In the EU, on the other hand, product market regulation has decreased. **Chart 14** shows the OECD Indicators of Product Market Regulation (PMR) across EU KLEMS countries as dots and the US as the line.[79] PMR has decreased drastically for all EU economies, while it has remained stable for the US. If we take this evidence at face value, it suggests that the US used to be more competitive, but that is no longer the case.

[78] Note that US concentration is based on Compustat while EU concentration is based on Amadeus. EU Herfindahl shown assumes the EU is one market, but the trend is similar using country Herfindahls.

[79] The PMR are a comprehensive and internationally-comparable set of indicators that measure the degree to which policies promote or inhibit competition in areas of the product market where competition is viable. They measure the economy-wide regulatory and market environments in 35 OECD countries in 1998, 2003, 2008 and 2013; they are consistent across time and countries. Not all years are available for all countries. For further details see (Koske & Barbiero, 2015).

Chart 14

OECD Economy-wide Product Market Regulation (PMR) Indices: US vs. Europe



Sources: OECD indicators of Product Market Regulation (PMR). PMR indices are a comprehensive and internationally-comparable set of indicators that measure the degree to which policies promote or inhibit competition in areas of the product market where competition is viable.

Relatedly, (Faccio & Zingales, 2017) study the impact of regulation on concentration, competition and prices for the mobile telecommunication sector. They find that pro-competition regulation reduces prices, but does not hurt quality of services or investments. They compare the U.S. and Europe and conclude that “U.S. consumers would gain $65bn a year if U.S. mobile service prices were in line with German ones and $44bn if they were in line with Danish ones.”

6.1.2 Intangibles: detailed discussion

Intangible investment is a critical driver of productivity growth. Historically, Europe has lagged the US in intangible investment. We want to understand if and when the EU has closed this intangible gap. We reach three broad conclusions.

First, we find fairly clear evidence of catching up: the EU appears to be closing the intangible gap.[80] Second, the gap is being closed by older firms, in contrast to the US where high intangible firms appear to be younger. Third, Europe appears to lead

80 The data for the capital stock is noisy, however. Depreciation assumptions vary widely for the EU, and are often much higher than in the US. This has material implications for capital accumulation and the comparison of intangible capital stock across geographies. Indeed using Compustat and the (Peters & Taylor, 2016) definition of intangible the gap appears to be fully closed; while using national accounts, a substantial gap remains.

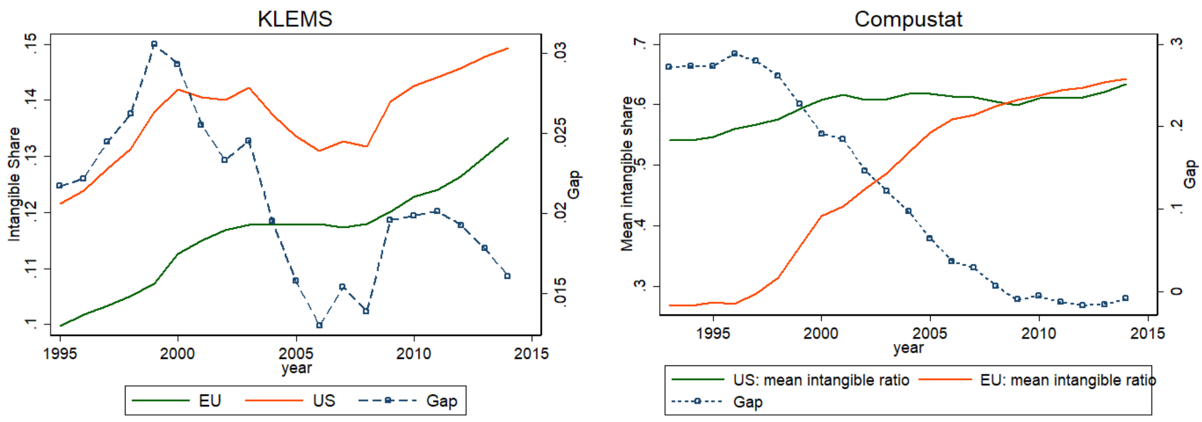
the US in certain industries while lag in others; and the differences are highly persistent.

Chart 15 compares the share of intangibles as a percent of total capital for the US and EU – as measured in KLEMS (left) and Compustat (right).

Both figures show that Europe has substantially closed the gap; though the decrease is far more pronounced when using Compustat.[81] This is likely for two reasons: (i) high depreciation assumptions in European national accounts compared to US; and (ii) the catch-up in Europe appears to be driven by larger, older firms, as we discuss below.

Chart 15

Comparison of Intangible Share based on Capital Stocks: KLEMS (left) and Compustat (right)



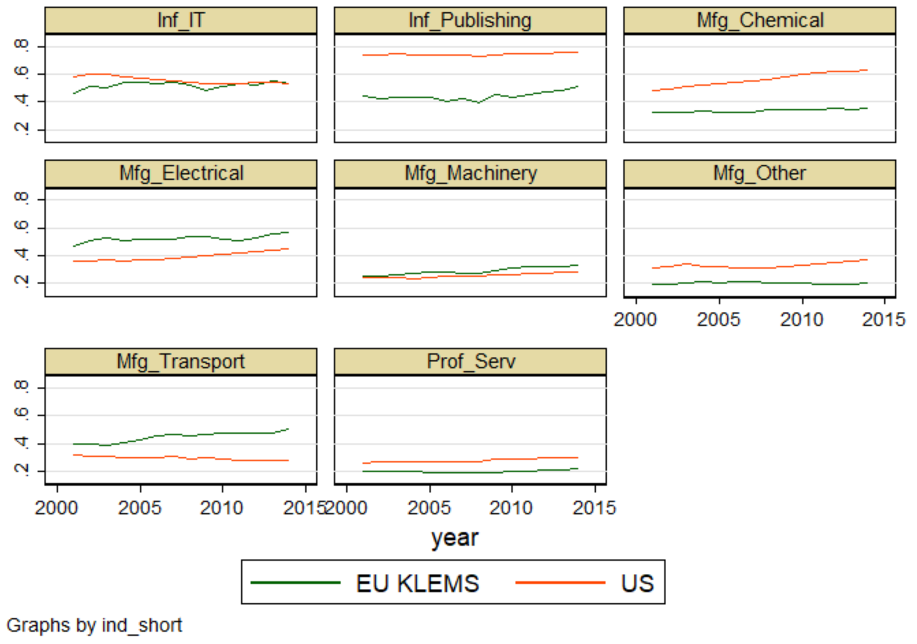
Sources: Annual data. Aggregate data sourced from BEA for US and KLEMS for Europe. Exclude Finance, Real Estate and Utilities. Compustat data from Compustat Global for Europe and Compustat NA for US. EU KLEMS series includes most countries since 1995 and all countries by 2000 (Germany and Netherlands enter in 2000).

Another interesting question is whether the US' lead in intangible exists across all industries. The answer is: not exactly. **Chart 16** shows the share of intangible capital by industry for the US and Europe for the 8 industries with the highest intangible share in the US as of 2001. As shown, the US leads Europe in some, but not all industries; most notably Information – Publishing and Manufacturing – Chemical. Europe, by contrast, appears to lead the US in heavy manufacturing industries (Electrical and Transport). At the industry level the gaps can be fairly persistent.

[81] National accounts report higher investment in Europe, but also much higher depreciation assumptions than the US. In Compustat, we use common depreciation assumptions which likely explains the faster catch up. Also, Compustat Global exhibits substantial missing values for SG&A expenses before 2005, which are input to the calculation of intangible capital. These values were backfilled using SG&A expenses after 2005 – thus capital levels in the early 1990s may be mis-estimated. See Section 3.3 for additional details. The difference in level between national accounts and Compustat comes from different assumptions on what spending flows count as intangible investments. For example, national accounts do not count any organizational capital, included as SG&A in the Compustat measure. Nonetheless, what appears robust is that the share of intangibles has increased drastically in Europe and now is very much in line with the US – at least for public firms.

Chart 16

Comparison of Intangible Share for EU and US by industry



Sources: Annual data sourced from BEA for US and KLEMS for Europe. EU KLEMS series includes all countries.

Chart 17 shows the gross investment rate in intangibles and CAPX for the 5 highest intangible industries in the US as of 2001. As before, we weigh across industries based on US-capital levels so all five industries are given the same weight.

Chart 17

Comparison based on investment at top 5 high intangible industries in US (national accounts data)

Sources: Authors calculations based on annual data from EU KLEMS for Europe and the US BEA for US.
Notes: Figure based on the 5 industries with the highest intangible share in the US as of 2001. These industries include Information Publishing, Information IT, Manufacturing Chemical, Manufacturing Electrical and Manufacturing Transport. Top two charts show the weighted average investment rate in intangible and tangible assets, respectively. Bottom left chart shows the depreciation rate. We include two depreciation series for the EU – one based on the geometric depreciation rates reported by KLEMS and one based on the implied depreciation using investment as well as changes in the level of capital. As shown, the implied depreciation is substantially higher than the reported geometric depreciation or the depreciation used in the US. Differences in depreciation rates disproportionately affect intangible assets, and therefore materially affect the stock of capital. The bottom-right plot shows that the higher intangible investment rate does not translate to a higher share of intangible capital (as percent of total capital) precisely due to differences in depreciation assumptions.

For these industries, investment rates in Europe are substantially higher for both intangibles and CAPX – and the difference is largest for intangibles. Nonetheless, the intangible gap appears to be growing. This is due to much larger depreciation assumptions in Europe. The bottom left plot shows the intangible capital depreciation assumed in EU KLEMS when computing capital services (EU (KLEMS)); implied by the EU KLEMS chained capital stocks and investment levels; and implied by BEA figures in the US. As shown, the EU depreciation rates implied by chained capital stocks far exceed those assumed by KLEMS and the BEA. These differences substantially affect the level of capital stock.

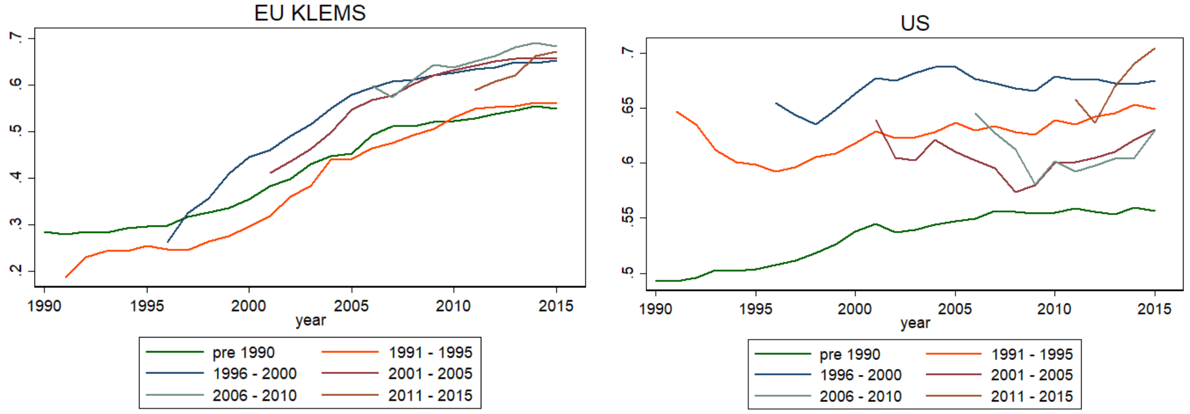
Ultimately, these results suggest that Europe is closing the intangible gap; but this is not entirely observable in National accounts. It is difficult to reconcile depreciation assumptions when comparing the level of capital stock between the US and Europe. This is why we use share of investment in intangibles as a measure of intangible intensity in our industry-level regressions instead of the share of intangible capital.

Chart 18 shows the share of intangible assets by entry year into Compustat, for Europe and the US. High intangible firms are largely concentrated in new entrants in the US. By contrast, older European firms appear to have substantially increased their intangible share over time – reaching levels similar to those observed in US firms.

Thus, it appears that European firms may have been slow to increase intangibles but have done so drastically starting in the late 1990s. Public firms are now largely similar in terms of intangible share between the US and Europe – at least according to the Peters & Taylor measure. Importantly, the share of intangible capital due to R&D and SG&A is largely similar across countries suggesting that the ‘type' of intangible capital is in fact similar.

Chart 18

Intangible share by Cohort: EU KLEMS vs. US



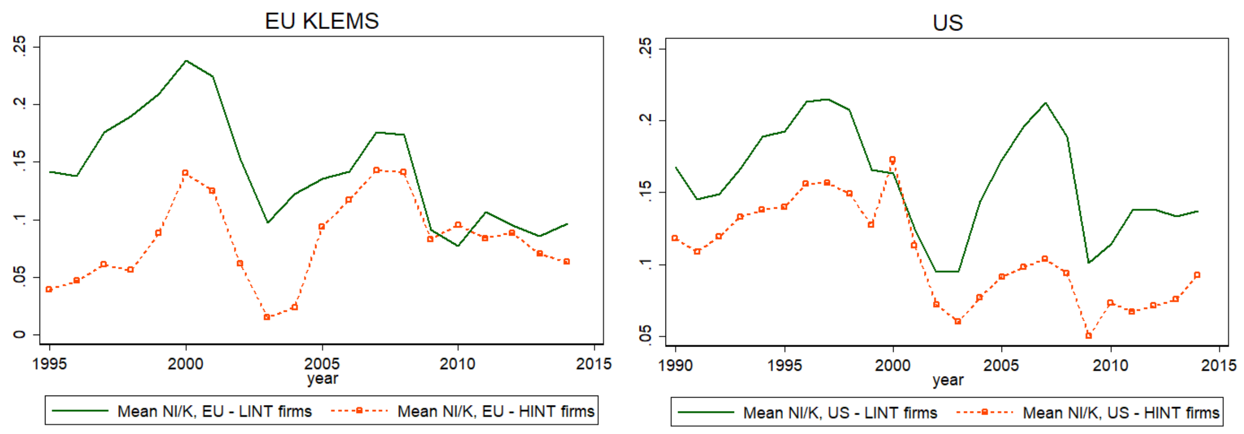
Sources: Annual data based on Compustat Global for Europe and Compustat NA for US.

Chart 19 shows that high-intangible firms tend to have lower investment rates. The figure plots total (CAPX plus intangible) NI/K by firms in the highest tercile of the intangibles distribution and those in the lowest tercile. In the US, high intangibles firms have consistently lower investment rates than low intangible firms, suggesting that there is a fundamental difference between these types of firms.[82]

82 We also find that both in the US and Europe high-intangibles firms hold more cash and have lower leverage (not reported here). This suggests a fundamental difference between these firms not only in investment, but also financing patterns.

Chart 19

Investment by high (HINT) and low intangible firms



Sources: Annual data based on Compustat Global for Europe and Compustat NA for US.
Notes: The figure shows total (CAPX plus intangible) net investment by high-intangibles (HINT) and low-intangibles (LINT) firms. HINT firms are defined as those in the highest tercile of intangible ratio in a given year, and LINT firms as those in the lowest tercile.

6.2 Firm level Results

The above results suggest that financial constraints and the rise of intangibles matter for measured investment. Both of these hypotheses are likely to affect firm-level investment more than industry-level investment. It is therefore natural to test them at the Firm-level.

Table 3 shows the results of regressing firm-level investment on measures of concentration, financial constraints and intangibles. All regressions include year and industry/firm fixed effects as noted. Columns 1 to 3 weigh observations by lagged total capital because we care about the economic impact on aggregate investment – particularly in the case of competition. Columns 4 to 9 weigh observations equally as financial constraints are more likely to affect smaller firms.

Columns 1 to 3 consider total net investment.

- Column 1 shows that firm-level Q explains investment. Column 2 shows that the Herfindahl has a negative and statistically significant coefficient. The coefficient is larger than observed at the industry-level (NI/K is more volatile and somewhat larger in the firm level data).
- Column 3 shows that the share of intangible assets is strongly significant: a high intangible ratio is associated with lower investment consistent with **Chart 19**. Comparing Tables 2 and 3, we see that competition is relatively more important at the industry level, while intangible investment is relatively more important at the firm level.

The remaining columns 4 to 9 focus on financial constraints.

- Columns 4 and 5 consider log(I/K) for CAPX.[83] Column 4 includes industry fixed effects; and column 5 includes firm fixed effects. Both columns show that more financially constrained firms decreased investment more in bad times.

- Columns 6 and 7 focus on intangibles. The former regresses the ratio of R&D expenses to assets and the latter log-I/K for intangible investment. As shown, most coefficients are intuitive and statistically significant for R&D/Assets but not so for intangible investment. This is likely due to measurement difficulties highlighted in Section 3.3.

- Columns 8 and 9 expand the sample to include all firms in the EU28 countries, since financial constraints are likely more severe at periphery economies than the core countries included in KLEMS. We test for the effect of financial constraints by interacting the log-leverage and maturity with a GIIPS dummy that is 1 in a GIIPS country (Greece, Ireland, Italy, Spain and Portugal) for those years when the corresponding sovereign bund spread exceeds 200bps. The dummy captures the effect of the Eurozone crisis. Consistent with the notion that low investment is explained by a weak macroeconomic environment, the GIIPS dummy has a negative, significant coefficient. The interaction terms also exhibit the expected signs, suggesting that financial constraints affected investment above and beyond Q.[84]

83 We use the log-gross investment rate because firm-level depreciation assumptions are not available – those reported in accounting statements often over-state depreciation (due to accounting rules) while also including only the portion of depreciation that is not included in cost of goods sold. An alternative is to use KLEMS-based depreciation. But this is available only for a subset of countries and we want to consider the full Eurozone sample given that financial constraints likely affected periphery economies more than those in the KLEMS population.

84 We note that our ability to test for financial constraints is somewhat limited given our focus on public firms – which tend to have better access to external financing than smaller, private firms. Nonetheless, we find some effect of financial constraints on investment.

Table 3

Firm level Net Investment: OLS Regressions

	(1) NIK	(2) NIK	(3) NIK	(4) Log I/K	(5) Log I/K	(6) XRD/AT	(7) Log I/K	(8) Log I/K	(9) Log I/K
Asset type	**All**	**All**	**All**	**Tangible**	**Tangible**	**R&D**	**Intangibles**	**Tangible**	**Tangible**
Log-Q (t-1) (CS)	**0.052** [6.86]**	**0.057** [7.33]**	**0.058** [7.17]**	**0.465** [19.39]**	**0.464** [16.91]**	**0.006+ [1.89]**	**0.211** [8.84]**	**0.503** [32.23]**	**0.478** [26.92]**
***Industry $Herfindahl_{c,j,t-1}$* (AM)**		**-0.107* [-1.98]**							
Intangible ratio (t-1) (CS)			**-0.093** [-6.44]**						
Log-Leverage (t-1) (CS)				-0.132** [-12.41]	-0.144** [-11.32]	-0.002 [-1.33]	-0.040** [-4.01]	-0.143** [-21.79]	-0.152** [-19.59]
Recession Dummy				-0.181** [-3.69]	-0.147** [-2.97]	-0.012** [-3.02]	-0.019 [-0.55]		
Recession x Log-leverage(t-1) (CS)				**-0.054** [-3.98]**	**-0.047** [-3.45]**	**-0.005* [-2.27]**	-0.009 [-0.95]		
Maturity (t-1) (CS)				-0.009 [-0.30]	0.008 [0.24]	-0.004 [-0.99]	-0.002 [-0.05]	0.006 [0.33]	0.008 [0.39]
Recession x Maturity(t-1)				**0.095* [1.96]**	**0.084+ [1.72]**	**0.001 [0.17]**	-0.019 [-0.53]		
GIIPS								-0.471** [-5.70]	-0.373** [-4.33]
GIIPS x Log-leverage(t-1)								**-0.101** [-2.91]**	**-0.098** [-2.63]**
GIIPS x Maturity(t-1)								**0.165+ [1.75]**	**0.092 [0.97]**
Log Age (t-1) (CS)	0.021** [2.73]	0.016* [2.03]	0.021** [2.70]	-0.170** [-7.13]	-0.141** [-3.59]	-0.002 [-0.51]	-0.037 [-1.30]	-0.156** [-10.76]	-0.209** [-8.41]
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	NO	NO	NO	NO	YES	NO	NO	NO	YES
Weighted by Capital	YES	YES	YES	NO	NO	NO	NO	NO	NO
Observations	27,441	20,583	27,425	25,119	25,119	9,463	17,648	55,328	55,328
R^2	0.182	0.171	0.209	0.126	0.126	0.006	0.05	0.121	0.121

Sources: Annual data from Compustat Global (CS) and Amadeus (AM). Herfindahl's provided by Sebnem Kalemli-Ozcan and Carolina Villegas-Sanchez.
Notes: Table shows the results of firm-level regressions of Net I/K and Log-I/K on predictor variables. All regressions include log-firm age as a control. Regressions in columns 1-7 are based on the EU KLEMS sample; while columns 8 and 9 broaden the sample to all EU countries to study the impact of recessions and sovereign stress in GIIPS countries on investment. Column 1 includes only firm-level Q. Column 2 adds the Herfindahl computed based on Amadeus for a given country-industry pair over the 1999-2012 period. Column 3 includes the share of intangible capital, computed using Compustat. Column 4 focuses on tangible investment and shows firms with higher leverage or shorter-term debt reduced investment more during recessions. Column 5 is the same as column 4 but including firm fixed effects. Column 6 focuses on R&D/AT and again shows that firms with higher leverage cut investment more. Column 7 includes intangible investment; the results are inconclusive likely due to difficulties in measuring intangible investment in Compustat (see Section 3.3.1.1 for details). Columns 8 and 9 add all Eurozone countries and replace the Recession dummy with a GIIPS dummy equal to one for Greece, Italy, Ireland, Portugal and Spain for the periods when they exhibit a spread greater than 200 bps over the Bund spread. Column 9 includes firm fixed effects. T-stats in brackets. Standard errors clustered at the firm level. + p<0.10, * p<0.05, ** p<.01.

7 Conclusion

We make two contributions.

First, we argue that the explanations for depressed investment in the US and in Europe are different. In Europe, investment is depressed because of depressed asset values, consistent with financial constraints, high risk premia, low expected demand and low expected cash flows. These effects are likely to be temporary and we can expect an increase in investment once sovereign and banking issues are resolved. In the US, investment is depressed because industries have become more concentrated over time and competitive pressures to invest are lacking. Our findings suggest that the weakness of investment is more cyclical in Europe and more structural in the U.S. They also suggest a role for anti-trust and product market regulation. Over the past 15 years, anti-trust has become weaker in the US and stronger in Europe, a reversal of the historical pattern of the past century. Our results suggest that this difference has real consequences for investment.

Second, we examine the role of intangible investment in the two regions. We find that the rising share of intangibles explains some but not all of the weakness in measured investment. At the same time, we find that EU firms have been catching up with their US counterparts in terms of intangible investment. But the processes of intangible deepening are different. In the US, intangible deepening happened by the entry of new firms with high intangible ratios, mostly in the 1990s and early 2000s. In Europe, the process was a bit slower and took place within incumbent firms that become more intangible intensive over time.

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Data Appendix

1 Country data

1.1 Overview

Country-level data is sourced primarily from the OECD. These data can be viewed at stats.oecd.org, but can also be downloaded directly onto STATA using the getData package.

We source data for the full economy and the non financial corporate (NFC) sector. When data for key economies is not available through the OECD, we obtain it directly from the corresponding National Statistical Institutes (NSIs). If data is not available at NSIs, we impute it from alternate sources as detailed below.

1.2 Data sampling and mapping

- **Sampling:**

Our primary country-level dataset is sourced from the following OECD tables. All data is sourced in Current prices, National Currency with an Annual frequency. Adjustments are described after the Table.

Table	Contents	Sector	Comments/definitions
SNA Table 1	Gross output and investment by asset type	Total economy	NA
SNA Table 710R	Consolidated Financial Balance Sheet	Total economy and NFC	Total liabilities computed as the difference between total financial liabilities (which include equity) and market value of equity
SNA Table 9B	Non financial balance sheet data, including fixed produced and non produced capital	Total economy and NFC	- Italy and Spain sourced separately (see below) - Values for Poland set missing because they are incomplete
SNA Table 14A	Nonfinancial transactions, including value added, operating surplus, capital formation and consumption	Total economy and NFC	NA

- **Adjustments:**
  - Non financial assets for Italy:
    - Some data is available through the OECD but it has very poor data quality.
    - Instead, we source data manually from dati.istat.it/Index using March 2017 edition.
    - Cover total economy and non-financial corporations.

- Data available only back to 2005; backfilled to 1995 based on the average ratio of NFC capital to KLEMS capital for Italy from 2005 to 2014.
- Note: Land included in value of dwellings and structures, so we set the value of non-produced assets equal to value of land under cultivation.

- NFC data for Spain:

  Data for Spain is sourced separately from www.bde.es/bde/en/secciones/informes/Publicaciones_an/Central_de_Balan.

  The BDE publishes results annually. However, estimates rely on changing databases over time, with varying levels of coverage. This implies that time-series are not entirely consistent over time (see BDE write-ups for more details).

  To address the comparability concerns, we use multiple databases that combined yield a stable time series; particularly around periods of stress. Namely, we use the following databases:

  - 1999 results for 1995-1997,
  - 2004 results for 1998-2002,
  - 2009 results for 2003-2006,
  - 2011 results for 2007-2011,
  - 2015 results for 2012-2015.

  These databases were chosen to (i) use results published after the periods of interest to account for potential 'fixes' implemented over time; and (ii) maintain common databases through the DotCom and Great Recession to better measure trends during periods of stress.

  The following tables are used for each year:

  - 3-9: Non financial transaction,
  - 3-10: Investment,
  - 3-12: Non financial assets,
  - 3-13: Financial liabilities.

  Each set of results relies on slightly adjusted document formats and field names, so we manually load and manipulate inputs for each table and year. We confirm that the resulting time series appear reasonable and do not include large jumps.

- Missing non-produced assets and computation of Q:

  Data for non-produced assets is missing for several countries and periods, yet is needed to compute country-level Q. Two approaches are used to estimate the corresponding values.

4. Countries that report value of Land

   Germany (>1998), Finland and Netherlands (>2001) report the value of land. We therefore estimate the value of non-produced assets based on the median ratio of non-produced assets to land assets by year, across those countries in EU28 that report both.

   For most countries, land accounts for the vast majority of non-produced assets. The median ratio of non-produced assets to land for those countries that report both ranges from 1.05-1.3 after 1996. As a result, this is expected to have a relatively limited impact on results.

5. Countries that do not report value of Land

   Germany (<1998), Netherlands (<2001), Austria and Belgium do not report the value of land. As a result, we estimate the value of non-produced assets based on the median ratio of non-produced assets to produced fixed assets by year, across those countries in EU28 that report both.

   Non-produced assets account for a relatively small share of assets in those countries where data is available. The median ratio of non-produced assets to produced fixed assets for those countries that report both is approximately 0.1 after 1996.

   We acknowledge that these are fairly broad assumptions. However, note that country-level Q is only used in the aggregate analyses of Section 4; hence is expected to have a relatively limited effect on our conclusions. To gain further comfort, we also confirm that (i) the resulting Q roughly aligns with the Compustat-implied Q; and (ii) conclusions are robust to using the Compustat and (Piketty & Zucman, 2014) measures of Q. The former is not affected by this issues, while the latter is less sensitive to mis-estimation of non-produced assets than our base measure of Q.

   Also note that the level of Q is substantially below 1 for some European countries. See the Appendix of (Piketty & Zucman, 2014) for a discussion.

- **Currencies:** When data is not reported in Euros, we convert to Euros in two steps:

  - First, convert to USD using the OECD reported exchange rates for each country.

  - Then, convert to EUR using the IMF USD to EUR exchange rate used to convert Compustat series – for consistency.

- Data initially reported in Euros is not adjusted.

- **Mapping:** No mapping is required as data is at the country-level.
- **Coverage:** Data for both Q and net investment is available starting on the following years, for each country in our core sample:
  - Austria, Belgium, Germany, Spain, Italy, Netherlands: 1996.
  - Finland: 2001.
  - France: 1995.

1.3 Key computed fields

The following are the key computed fields based on the country dataset:

- Investment rate: ratio of Gross fixed capital formation (NFP51P) to lagged Fixed Assets (N11).
- Depreciation rate: ratio of Gross fixed capital consumption (NFK1MP) to lagged Fixed Assets (N11).
- Net investment rate: Gross investment rate minus the depreciation rate.
- Tobin's Q: the sum of (Market value of Equities (LF51LI), value of total liabilities (LFLI - LF51LI) and value of Financial Assets (LFAS) divided by the current value of capital (defined as the sum of produced and non-produced assets).
- Net Operating Surplus: Gross operating surplus (NFB2G_B3GP) minus depreciation (NFK1MP).
- OS/K: Net operating surplus over produced fixed assets (N11).

The following table presents summary statistics for the country-level NFC series:

	Obs	Mean	Std. Dev.	Min	Max
I/K	0.104	0.022	0.055	0.169	0.104
NI/K	0.022	0.017	-0.010	0.083	0.022
OS/K	0.104	0.027	0.050	0.191	0.104
I/GOS	0.585	0.128	0.362	1.085	0.585
NI/NOS	0.221	0.191	-0.191	1.193	0.221
Q	0.792	0.429	0.303	2.041	0.792

2 OECD Industry data

2.1 STAN

2.1.1 Overview

Data sourced from OECD Table STANI4_2016, which is based on ISIC Rev. 4 segments. These data is split by industry and covers the full economy. It includes measures of production, intermediate inputs, value added, labour costs, operating surplus, employment, and capital. Note that only the total capital stock is available, which limits our ability to study differences in investment across asset types (e.g., structures, equipment, intangibles).

2.1.2 Data sampling and mapping

- **Sampling:**
  - Data sourced directly from OECD for all European countries for which data is available. This includes current price, volume and deflator series for most quantities.
  - Investment and profitability ratios for Denmark set to missing due to widespread data issues. No other exclusion restrictions are applied.
- **Adjustments:**
  - We re-define the gross-operating-surplus to be based on basic prices rather than factor prices for consistency with KLEMS:
    - GOS = Value added, current prices - Labour costs (compensation of employees).
    - NOS = Value added, current prices - Labour costs (compensation of employees) - Consumption of fixed capital.
  - We also compute the implied depreciation rate in volumes, using the ‘Gross Fixed Capital Formation, deflators’ (GFCP). Namely:
  - Gross Fixed Capital Consumption, Volumes = CFCC * 100 / GFCP.
  - The associated depreciation rate is used to compute volume-based net investment rates.
  - Neither Spain nor UK are covered in STAN. We use KLEMS to supplement them.

- We also exclude the same industry segments in STAN as in KLEMS. See below for additional details.

- **Mapping:**
  - Industry segments are mapped to the KLEMS segments, as defined below. Both KLEMS and STAN are defined based on ISIC Rev. 4, yet STAN provides more granularity than KLEMS. As a result, we can map all STAN segments to KLEMS segments directly.

- **Currencies:** When data is not reported in Euros, we convert to Euros in two steps:
  - First, convert to USD using the OECD reported exchange rates for each country.
  - Then, convert to EUR using the IMF USD to EUR exchange rate used to convert Compustat – for consistency.
  - Data initially reported in Euros is not adjusted.

- **Data availability:** The following are the initial dates of data availability by country for our core sample. Note, however, that data is available for some but not all industries in some country-year pairs. The year 1995 is the first one when the vast majority of country-industry pairs are populated; hence we use this period as the basis of our analyses.
  - 1970 BEL,
  - 1975 FIN,
  - 1976 AUT,
  - 1978 FRA,
  - 1980 ITA,
  - 1987 NLD,
  - 1991 DEU,
  - 1993 SWE.

2.1.3 Key computed fields

- Investment rate (IK): ratio of “Gross fixed capital formation (GFCF)” to lagged “Net capital stock, current replacement costs (CAPN)”.
- Net investment rate (NIK): ratio of “Gross fixed capital formation, current replacement cost (GFCF)” minus “Consumption of fixed capital, current

replacement cost (CFCC)" to lagged "Net capital stock, current replacement costs (CAPN)".

- Investment rate, volumes (IKQ): ratio of "Gross fixed capital formation, volumes (GFCK)" to lagged "Net capital stock, volumes (CPNK)".
- Net investment rate (NIKQ): ratio of "Gross fixed capital formation, volumes (GFCK)" minus "Consumption of fixed capital" to lagged "Net capital stock, volumes (CAPK)".

2.2 ANBERD

We also source R&D expense data from OECD Table ANBERD_REV4, which is based on ISIC Rev. 4 segments. We use the main activity categorization because it is consistently available across more countries. That said, note that the product field categorization provides a longer history for some countries (e.g., France).

As the STAN data, ANBERD R&D data are mapped to KLEMS segments. We use these data to validate some of the Compustat trends but do not use it in any of our final analyses. We instead use KLEMS' measure of intangible capital to capture a broader set of intangible investment.

We apply the same currency conversion process as for STAN and OECD national accounts.

2.3 SDBS

We source business demographic data from OECD Table SDBS_BDI_ISIC4, which is based on ISIC Rev. 4 segments. This dataset contains measures of the number of active employer enterprises, as well as the number of enterprise births and deaths.

Unfortunately, these data are available over very short periods for some countries (e.g., data for Germany is only available from 2012 on), which does not support robust analyses. We therefore rely on other data sources to obtain more robust measures of competition.

But these data can still be informative. We study the entry/exit trends for those countries where data is consistently available for several years. We find that entry has remained relatively stable across those EU KLEMS countries for which data is available. Exit increased at the height of the Great Recession – most notably in Spain – but has decreased since.

3 KLEMS industry data

3.1 Overview

KLEMS EU data is sourced directly from the KLEMS EU website. We use the 2016 release of the Statistical Module of KLEMS. This release covers data up to 2014 for 10 major European economies (Austria, Belgium, Germany, Finland, France, Italy, Netherlands, Spain, Sweden, and United Kingdom). Note, however, that only output data is available for Belgium – capital stock and investment figures are missing.

Several features are worth noting:

- The dataset covers the full economy for each industry.
- The time period coverage is 1995-2014 for most countries and industries. Notably, data for Germany is only available from 2000.
- The data on output, value added, employment, capital formation and capital stocks is almost always consistent with Eurostat at the corresponding industry levels.
- That said, capital services and therefore depreciation rates used in the EU KLEMS database are not based on National Accounts. Instead, KLEMS systematically applies geometric depreciation rates to the capital stock. This is because implicit depreciation rates from official data are often highly volatile.

  Because of this discrepancy, evolving the capital stock based on KLEMS investment and depreciation rates does not yield the total capital stock in National Accounts. This is particularly relevant for high intangible industries where depreciation rates differ more.

  Despite these differences, we choose to apply KLEMS depreciation rates for consistency with profitability amounts and because the depreciation rates implied by national accounts are sometimes excessively high and excessively volatile.

  See http://www.euklems.net/TCB/2016/Metholology_EU%20KLEMS_2016.pdf for additional details on KLEMS EU.

Data series

The following key data series are used in our analyses, each split across ten different asset types. Additional data series are also available.

- Capital and Investment
  - Nominal gross fixed capital formation, in millions of national currency.

- Real gross fixed capital formation volume (2010 prices).
- Gross fixed capital formation price index (2010=100.0).
- Nominal capital stock, in millions of national currency.
- Real fixed capital stock (2010 prices).
- EU KLEMS Geometric depreciation rates (constant over time, but differentiated by asset type and industry).

- Values
  - VA: Gross value added at current basic prices (in millions of national currency).
  - GO: Gross Output at current basic prices (in millions of national currency).
  - COMP: Compensation of employees (in millions of national currency).
  - LAB: Labour compensation (in millions of national currency).
  - CAP: Capital compensation (in millions of national currency).

Asset types

1. I_IT: Computing equipment.
2. I_CT: Communications equipment.
3. I_Soft_DB: Computer software and databases.
4. I_TraEq: Transport Equipment.
5. I_OMach: Other Machinery and Equipment.
6. I_OCon: Total Non-residential investment.
7. I_RStruc: Residential structures.
8. I_Cult: Cultivated assets.
9. I_RD: Research and development.
10. I_OIPP: Other IPP assets.

3.2 Data sampling and mapping

- **Sampling:**
  - Data is sourced across all countries as reported.
  - We exclude Financials to focus on the corporate sector; and Real Estate given its unique experience during the crisis. We also exclude Utilities (Electricity, Gas and Water Supply); Public administration and defence; activities of households as employers; and activities of extraterritorial organizations given the influence of government actions on their investment and the limited coverage of Compustat Global for these industries. This leaves us with 25 industry groupings for our analyses. All other datasets are mapped to these 25 industry groupings.
- **Adjustments:**
  - Depreciation rates are not available for the combined segments D45T47 (G) and D49T53 (H) (see mapping for details). For D45T47, we use the simple average depreciation rate across the three sub-segments. For D49T53, we use the depreciation of the combined D49T52 segment, which accounts for the vast majority of assets. In both cases, depreciation rates are very similar across subsegments so these choices are expected to have a limited effect on the results.
- **Mapping:**
  - Data is available at the sector level (19 groups) following the ISIC Rev. 4 hierarchy. Data for some sectors is further broken out (e.g., manufacturing is split into 11 groups). In principle, this leads to 34 categories. But capital data is not available for some of these granular segments (e.g., capital data for segments D45, D46 and D47 is missing for several countries, so we combine D45T47 into one segment). In the end, we use the most granular segmentation for which data is available, which corresponds to 31 KLEMS categories. We also exclude six segments as discussed in the main text (financials, real estate, etc.).
  - The following table shows all KLEMS segments. Those noted with 1 as included are included in our analyses. Those listed as 'excluded' are entirely excluded from our analyses. Those with a '0' are captured by other (typically more granular) segments. All other datasets are mapped to these segments.

KLEMS code	Industry name	Included?	Segment code
TOT	All	0	
MARKT	Mkt	0	
A	Agriculture	1	D01T03
B	Mining	1	D05T09
C	Mfg	0	
10-12	Mfg_Food	1	D10T12
13-15	Mfg_Textiles	1	D13T15
16-18	Mfg_Wood	1	D16T18
19	Mfg_Petroleum	1	D19
20-21	Mfg_Chemical	1	D20T21
22-23	Mfg_Rubber	1	D22T23
24-25	Mfg_Metal	1	D24T25
26-27	Mfg_Electrical	1	D26T27
28	Mfg_Machinery	1	D28
29-30	Mfg_Transport	1	D29T30
31-33	Mfg_Other	1	D31T33
D-E	Utilities	Excluded	D35T39
F	Construction	1	D41T43
G	WH_and_RET_Trade	1	D45T47
45	Trade_motor	0	
46	WH_nonmotor	0	
47	Retail_nonmotor	0	
H	Transp_and_storage	1	D49T53
49-52	Transp_and_storage	0	
53	Courier	0	
I	Acc_and_food	1	D55T56
J	Inf_and_comp	0	
58-60	Inf_Publishing	1	D58T60
61	Inf_Telecom	1	D61
62-63	Inf_IT	1	D62T63
K	FS	Excluded	D64T66
L	RE	Excluded	D68
M-N	Prof_Serv	1	D69T82
O-U	Com_Serv	0	
O	Public_Adm	Excluded	D84
P	Education	1	D85
Q	Health	1	D86T88
R-S	Arts_and_Rec	0	
R	Arts_and_Rec	1	D90T93
S	Other_Serv	1	D94T96
T	HH	Excluded	D97T98
U	Other_Serv	Excluded	D99

- **Currency:** When reported data is not in Euros (UK and SWE), we convert to Euros in two steps:
  - First, convert to USD using the OECD reported exchange rates for each country.
  - The convert to EUR using the IMF USD to EUR exchange rate used to convert Compustat – for consistency.
  - Data initially reported in Euros is not adjusted.
  - We use the same conversion process as the one used for OECD data to avoid introducing additional sources of discrepancy, particularly as capital quantities are consistent.
- **Data availability:** The following are the initial years when net investment rate data is available for each country in our core sample:
  - ESP 1970,
  - FRA 1978,
  - FIN 1982,
  - SWE 1993,
  - AUT 1995,
  - ITA 1995,
  - GBR 1997,
  - NLD 2000,
  - DEU 2000.

  Because data for Netherlands and Germany is only available from 2000 onwards, we restrict some of our analyses based on KLEMS to the post-2000 period (post-2001 for investment rates).

3.3 Key computed fields

The following investment and profitability ratios are computed at the industry x asset type level:

- KLEMS depreciation amounts (DEP): computed as the product of last period capital (either total or in 2010 prices) and the industry-level depreciation rate.
- Implied depreciation amounts (IMPDEP): $K_t - K_{\{t+1\}} + I_t$; used for comparison against KLEMS depreciation rate.

- Investment rate (IK): ratio of Nominal gross fixed capital formation (I) to lagged Nominal capital stock (K).
- Real investment rate (IKQ): ratio of Real gross fixed capital formation (Iq) to lagged Real capital stock (Kq).
- Pretax GOS: Value added minus compensation expenses.[85]

We also group asset types into the following categories:

- Intangibles
  - I_RD: Research and development.
  - I_OIPP: Other IPP assets.
  - I_Soft_DB: Computer software and databases.
- Non-Intangibles, ex. Res
  - I_IT: Computing equipment.
  - I_CT: Communications equipment.
  - I_TraEq: Transport Equipment.
  - I_OMach: Other Machinery and Equipment.
  - I_OCon: Non-residential structures.
  - I_Cult: Cultivated assets.
- Residential assets
  - I_RStruc: Residential structures.

  For some figures, we also define ‘structures’ as OCon and ‘equipment’ as all non-intangible ex. Residential assets except for OCon.

[85] Note that taxes are not available, so we compute pre-tax GOS from STAN as well for consistency. We do not compute the net operating surplus due to the lack of tax data at the country-industry segment (from a common source).

The following table presents summary statistics for key country-industry series:

Series	Granularity	Source	Obs	Mean	Std. Dev.	Min	Max
NI/K - Total	Country x Industry	STAN	3619	0.016	0.039	-0.098	0.540
NI/K - Total	Country x Industry	KLEMS	2933	0.034	0.044	-0.045	0.194
NI/K - Non-IP	Country x Industry	KLEMS	2909	0.030	0.042	-0.050	0.184
NI/K - IP	Country x Industry	KLEMS	2909	0.070	0.088	-0.078	0.435
Median Q	Industry	Compustat	3812	1.242	0.312	0.663	4.568
Median Q	Country x Industry	Compustat	3812	1.340	0.590	0.369	7.596
Herfindahl	Country x Industry	Amadeus	2688	0.081	0.114	0.020	1.000
Herfindahl	Industry	Amadeus	2688	0.035	0.003	0.032	0.045
Investment Share	Industry	KLEMS	3648	0.274	0.218	0.015	0.861

4 US data

4.1 Overview

We gather three types of data for the US, in order to contrast the US and Europe. See (Gutiérrez & Philippon, 2016) for additional details.

- **Aggregate data:** Aggregate data on funding costs, profitability, investment and market value for the US Economy and the non financial sector is gathered from the US Flow of Funds accounts through FRED. These data are analogous to the Country data downloaded from the OECD, although exhibit slightly different categorizations in some cases. We use these data in the construction of aggregate Q; and to reconcile and ensure the accuracy of more granular data.
- **Entry and exit data:** We also gather data on aggregate firm entry and exit from the Census BDS.
- **Industry data:** Industry-level investment and profitability data – including measures of private fixed assets (current-cost and chained values for the net stock of capital, depreciation and investment) and value added (gross operating surplus, compensation and taxes) – are gathered from the Bureau of Economic Analysis (BEA).

A few items are worth highlighting:

- US Fixed assets data is available in three categories: structures, equipment and intellectual property (which includes software, R&D and expenditures for entertainment, literary, and artistic originals, among others). We aggregate the KLEMS asset types into these three categories for comparison as noted above.

- Investment and profitability data are available at the sector (19 groups) and detailed industry (63 groups) level, in a similar categorization as the 2007 NAICS Level 3. We map these segments to the 31 segments constructed from KLEMS as outlined in the Table below. Capital data is available across industries from 1947, while output data is available from 1987 onward.

  Industries highlighted in orange do not map one-to-one to ISIC industries. They were mapped based on the relative size of the underlying industries. The remaining ones can be mapped essentially one-to-one (although small discrepancies may remain given the differences between ISIC and NAICS).

4.2 Data sampling and mapping

BEA industry	KLEMS industry	beacode	klemscode
Farms	AGRICULTURE, FORESTRY AND FISHING	110	D01T03
Forestry, fishing, and related activities	AGRICULTURE, FORESTRY AND FISHING	113	D01T03
Oil and gas extraction	MINING AND QUARRYING	211	D05T09
Mining, except oil and gas	MINING AND QUARRYING	212	D05T09
Support activities for mining	MINING AND QUARRYING	213	D05T09
Utilities	ELECTRICITY, GAS AND WATER SUPPLY	220	D35T39
Construction	CONSTRUCTION	230	D41T43
Wood products	Wood and paper products; printing and reproduction of recorded media	321	D16T18
Nonmetallic mineral products	Rubber and plastics products, and other non-metallic mineral products	327	D22T23
Primary metals	Basic metals and fabricated metal products, except machinery and equipment	331	D24T25
Fabricated metal products	Basic metals and fabricated metal products, except machinery and equipment	332	D24T25
Machinery	Machinery and equipment n.e.c.	333	D28
Computer and electronic products	Electrical and optical equipment	334	D26T27
Electrical equipment, appliances, and components	Electrical and optical equipment	335	D26T27
Motor vehicles, bodies and trailers, and parts	Transport equipment	336	D29T30
Other transportation equipment	Transport equipment	336	D29T30
Furniture and related products	Other manufacturing; repair and installation of machinery and equipment	337	D31T33
Miscellaneous manufacturing	Other manufacturing; repair and installation of machinery and equipment	338	D31T33
Food and beverage and tobacco products	Food products, beverages and tobacco	311	D10T12
Textile mills and textile product mills	Textiles, wearing apparel, leather and related prodcuts	313	D13T15
Apparel and leather and allied products	Textiles, wearing apparel, leather and related prodcuts	315	D13T15
Paper products	Wood and paper products; printing and reproduction of recorded media	322	D16T18
Printing and related support activities	Wood and paper products; printing and reproduction of recorded media	323	D16T18
Petroleum and coal products	Coke and refined petroleum products	324	D19
Chemical products	Chemicals and chemical products	325	D20T21
Plastics and rubber products	Rubber and plastics products, and other non-metallic mineral products	326	D22T23
Wholesale trade	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES	420	D45T47

BEA industry	KLEMS industry	beacode	klemscode
Retail trade	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES	440	D45T47
Air transportation	TRANSPORTATION AND STORAGE	481	D49T53
Railroad transportation	TRANSPORTATION AND STORAGE	482	D49T53
Water transportation	TRANSPORTATION AND STORAGE	483	D49T53
Truck transportation	TRANSPORTATION AND STORAGE	484	D49T53
Transit and ground passenger transportation	TRANSPORTATION AND STORAGE	485	D49T53
Pipeline transportation	TRANSPORTATION AND STORAGE	486	D49T53
Other transportation and support activities \2	TRANSPORTATION AND STORAGE	487	D49T53
Warehousing and storage	TRANSPORTATION AND STORAGE	493	D49T53
Publishing industries (includes software)	Publishing, audiovisual and broadcasting activities	511	D58T60
Motion picture and sound recording industries	Publishing, audiovisual and broadcasting activities	512	D58T60
Broadcasting and telecommunications	Telecommunications	513	D61
Information and data processing services	IT and other information services	514	D62T63
Federal Reserve banks	FINANCIAL AND INSURANCE ACTIVITIES	521	D64T66
Credit intermediation and related activities	FINANCIAL AND INSURANCE ACTIVITIES	522	D64T66
Securities, commodity contracts, and investments	FINANCIAL AND INSURANCE ACTIVITIES	523	D64T66
Insurance carriers and related activities	FINANCIAL AND INSURANCE ACTIVITIES	524	D64T66
Funds, trusts, and other financial vehicles	FINANCIAL AND INSURANCE ACTIVITIES	525	D64T66
Real estate	REAL ESTATE ACTIVITIES	531	D68
Rental and leasing services and lessors of intangible assets \3	REAL ESTATE ACTIVITIES	532	D68
Legal services	PROFESSIONAL, SCIENTIFIC, TECHNICAL, ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	541	D69T82
Computer systems design and related services	PROFESSIONAL, SCIENTIFIC, TECHNICAL, ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	541	D69T82
Miscellaneous professional, scientific, and technical services \4	PROFESSIONAL, SCIENTIFIC, TECHNICAL, ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	541	D69T82
Management of companies and enterprises \5	PROFESSIONAL, SCIENTIFIC, TECHNICAL, ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	550	D69T82
Administrative and support services	PROFESSIONAL, SCIENTIFIC, TECHNICAL, ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	561	D69T82
Waste management and remediation services	ELECTRICITY, GAS AND WATER SUPPLY	562	D35T39
Educational services	Education	610	D85
Ambulatory health care services	Health and social work	621	D86T88
Hospitals	Health and social work	622	D86T88
Nursing and residential care facilities	Health and social work	623	D86T88
Social assistance	Health and social work	624	D86T88
Performing arts, spectator sports, museums, and related activities	Arts, entertainment and recreation	711	D90T93
Amusements, gambling, and recreation industries	Arts, entertainment and recreation	713	D90T93
Accommodation	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	721	D55T56
Food services and drinking places	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	722	D55T56
Other services, except government	Other service activities	810	D94T96

4.3 Key computed fields

We use effectively the same definitions as for European data:

- Industry-level gross investment rates: ratio of 'Investment in Private Fixed Assets' to lagged 'Current-Cost Net Stock of Private Fixed Assets'
- Depreciation rates: ratio of 'Current-Cost Depreciation of Private Fixed Assets' to lagged 'Current-Cost Net Stock of Private Fixed Assets'
- Net investment rates: gross investment rate minus the depreciation rate
- Pre-tax Gross Operating Surplus: Gross Operating Surplus provided by the BEA plus taxes
- Net Operating Surplus: Gross Operating Surplus minus Current-Cost Depreciation of Private Fixed Assets
- OS/K: 'Net Operating Surplus' over the lagged 'Current-Cost Net Stock of Private Fixed Assets'

Investment rates are computed across all asset types, as well as separating intellectual property from structures and equipment. We use the current cost values for reported results, but all conclusions are robust to using Chained values.

5 Firm data

5.1 Overview

Firm level data is sourced from Compustat Global and Compustat North America, as well as from merged vintages of Bureau van Dijk's (BvD) Amadeus and Orbis databases. Compustat has a relatively high data quality, but only contains listed firms. BvD data has comparatively lower quality, but contains private as well as public firms.

The Compustat data is our main source for firm-level regression analyses. It is downloaded through WRDS. BvD data is used to compute measures of concentration. We compute these on the merged vintages of Kalemli-Ozcan et al. (2015), who generously ran our code on their dataset.

5.2 Compustat

We obtain firm-level data for our European sample from Compustat Global. In particular, we use the Fundamentals Annual database for financials, and the Securities Daily database for market values. Our sampling and industry mapping procedures, as well as variable definitions are described in the main text.

The following table shows the number of firms in each of the countries.

Country	Number of firms
Austria	121
Belgium	155
Germany	951
Spain	193
Finland	171
France	1033
Italy	364
Netherlands	256
Total	3244

The following table presents summary statistics for key variables.

	Obs	Mean	Std. Dev.	Min	Max
NI/K - Total	27441	0.108	0.208	-0.153	1.146
I/K - Total	27441	0.230	0.207	0.005	1.271
I/K - CAPX	26438	0.406	0.561	0.008	3.023
I/K - IP	18704	0.223	0.131	0.012	0.597
R&D/AT	10745	0.060	0.095	0.000	1.817
Intangible Ratio	34229	0.498	0.322	0.000	0.994
Leverage	34305	0.212	0.160	0.000	0.649
Maturity	32364	0.552	0.301	0.000	2.250

The rest of this Section discusses how we compute market values, as well as intangible capital and investment.

5.2.1 Market values

In Compustat North America the market value of a firm's equity is easily computed multiplying shares outstanding and end-year stock price (items CSHO and PRCC_F, respectively).

The items CSHO and PRCC_F are not available in Compustat Global – Fundamentals Annual. Instead, market values are obtained from Compustat Global's Securities Daily database, which reports daily shares outstanding and stock prices, separately for each issue of a corporation. Since the dataset is very large, we impose the restriction MONTHEND == 1 to obtain only end-of-month stock prices.

It is important to note that Security Daily does not only report stock issues, but also bonds, preferred stock and other listed liabilities. The type of the issue can be identified by the item TPCI. We are only interested in computing the value of commons stock (TPCI = 0), and drop all other observations.

Firms are identified through the GVKEY identifier. Within each firm, a stock issue is identified by the issue ID (item IID). The combination of GVKEY and IID uniquely identifies separate stock issues.

To compute the market value of a company's common stock, our overall strategy is to sum across the separate issues. Since issues of the same firm may be in different currencies it is important to first convert each issue separately to a common currency before summing across them. We convert all market values to Euros using the conversion rates of the IMF International Financial Statistics.

A problem with this procedure is that some of the separate issues seem instead to be duplicates. Even though GVKEY-IID uniquely identifies observations in the data, some of the separate issues have exactly the same number of shares outstanding. I.e. there are duplicates in terms of GVKEY, IID, DATADATE and CSHOC (roughly 6.5% of the observations in our sample). Checking some of these cases manually on the Bloomberg website, we confirmed that the actual number of shares outstanding is not the sum across these observations, but rather that these are duplicate observations.

Simply summing the market values across stock issues would therefore over-estimate the market value of some firms. To remove duplicates, we apply the following procedure:

1. We find that within the duplicates often only one of the duplicates is currently active (secstat == "A"), while the others are inactive (secstata == "I"). We remove the inactive duplicate.

2. Similarly, often only one of these duplicates has earnings participation flag yes (EPF="Y"), the others no (EPF="N"). We remove the one with no.

3. After this, only 3000 out of 1.8m observations remain duplicates, and we remove the remaining duplicates randomly.

After removing duplicates, we define the market value of a stock issue as the shares outstanding (CSHOC) times the price converted to Euros. We compute the total month-end market value of a firm by summing across market values of stock issues. Then, to compute firm-level Q, we assign the market value as of the firm's reporting month, identified by the item FYRC.

5.2.2 Intangibles: capitalized and on-balance sheet

Most intangibles do not appear on a firm's balance sheet. To measure the stock of intangible capital, we capitalize R&D expenditures and a portion of SG&A expenditures. For the US, this approach has been widely used in the literature. For example, the intangible stock measured by (Peters & Taylor, forthcoming) can be downloaded through WRDS. The same procedure has not been applied to European firms. We attempt to replicate it, but deviate in some cases due to data availability.

EU public firms report financials under IFRS since 2005. In contrast to US GAAP, IFRS allows firms to capitalize some R&D expenditures under certain conditions. GAAP requires all R&D and SG&A expenses to be expensed. Still, we find that the stock of on-balance sheet intangibles from capitalized R&D is relatively small in European countries – compared to what is obtained using the assumptions of (Peters & Taylor, forthcoming).

The table below summarizes the mean and median of capitalized and balance sheet intangibles relative to total intangibles. Especially after the introduction of IFRS in 2005, the two sub-components play a very similar role in Europe relative to the US. While there is some bias, this gives us confidence that intangible capital in Europe is not substantially over-estimated.

Table

Summary Statistics on Intangible Capital

	Post 1995			
	Capitalized / Total Intangibles		Balance-sheet / Total Intangibles	
	Mean	Median	Mean	Median
Europe	0.809	0.923	0.323	0.126
US	0.827	0.946	0.235	0.090
	Post 2005			
	Capitalized / Total Intangibles		Balance-sheet / Total Intangibles	
	Mean	Median	Mean	Median
Europe	0.790	0.901	0.242	0.110
US	0.814	0.913	0.240	0.108

Intangibles: treatment of SG&A

Before 2005 many European firms report in national accounting standards. These standards do not always require reporting SG&A expenditures, hence these are often missing. Because we capitalize a portion of SG&A expenditures as intangible assets, this poses a problem for our computations. We confirmed with S&P that SG&A observations set to zero are indeed missing. Prior to 2005, 80% of all observations report zero SG&A, compared to only 14% after 2005.

Our approach is to replace zero SG&A values by backfilling them. For each firm, we interpolate SG&A spending using Stata's built in interpolation command ipolate. To avoid interpolating extreme values, we cap interpolated values at zero from below. At the top, we cap if the interpolated value exceeds the 99th percentile of SG&A spending in a given year, or if it exceeds the firm's highest ever observed SG&A spending.

It is important to note that we only use the backfilled SG&A values to compute the capital stock. For our investment series, we use the original values, and set zeros to missing.

We acknowledge that this approach is not perfect, and future research should focus on how to better measure intangible capital for European firms. As a check, the table below reports the fraction of the aggregate capital stock (summed across all firms), by year and separately pre- and post 2005. It gives us comfort that the relative importance of SG&A and R&D seems to be very similar before and after the widespread adoption of IFRS.

Table

Fraction SG&A and R&D of total capitalized intangible capital

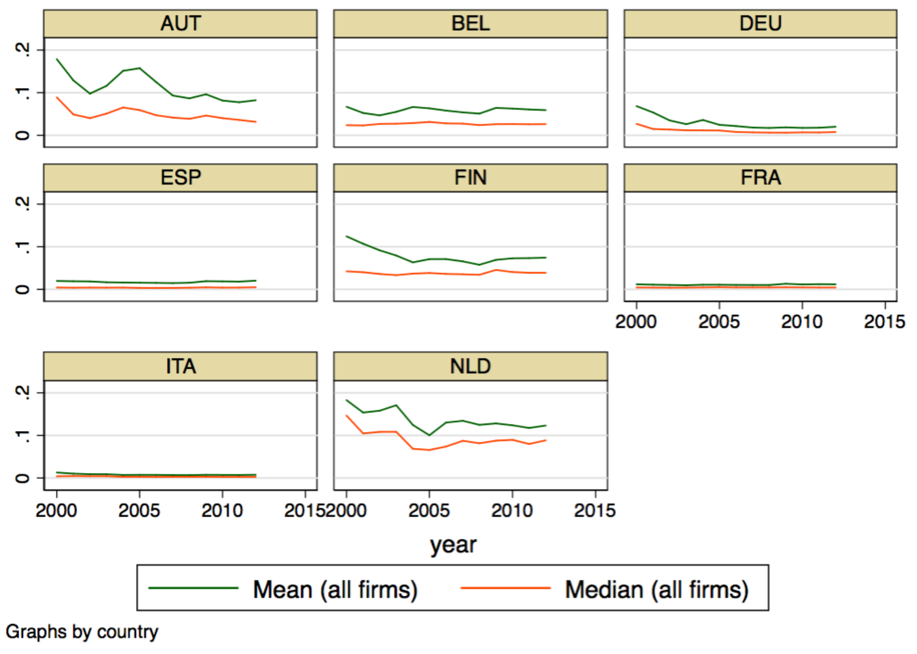
Year	SG&A	R&D	Year	SG&A	R&D
1990	0.454	0.546	2005	0.498	0.502
1991	0.451	0.549	2006	0.500	0.500
1992	0.457	0.543	2007	0.503	0.497
1993	0.474	0.526	2008	0.495	0.505
1994	0.476	0.524	2009	0.494	0.506
1995	0.494	0.506	2010	0.494	0.506
1996	0.524	0.476	2011	0.491	0.509
1997	0.512	0.488	2012	0.483	0.517
1998	0.513	0.487	2013	0.483	0.517
1999	0.517	0.483	2014	0.484	0.516
2000	0.507	0.493	2015	0.481	0.519
2001	0.499	0.501	2016	s0.474	0.526
2002	0.505	0.495			
2003	0.497	0.503			
2004	0.490	0.510			
Mean (pre-2005)	0.499	0.501	Mean (post-2005)	0.491	0.509

5.3 BvD merged Amadeus-Orbis vintages

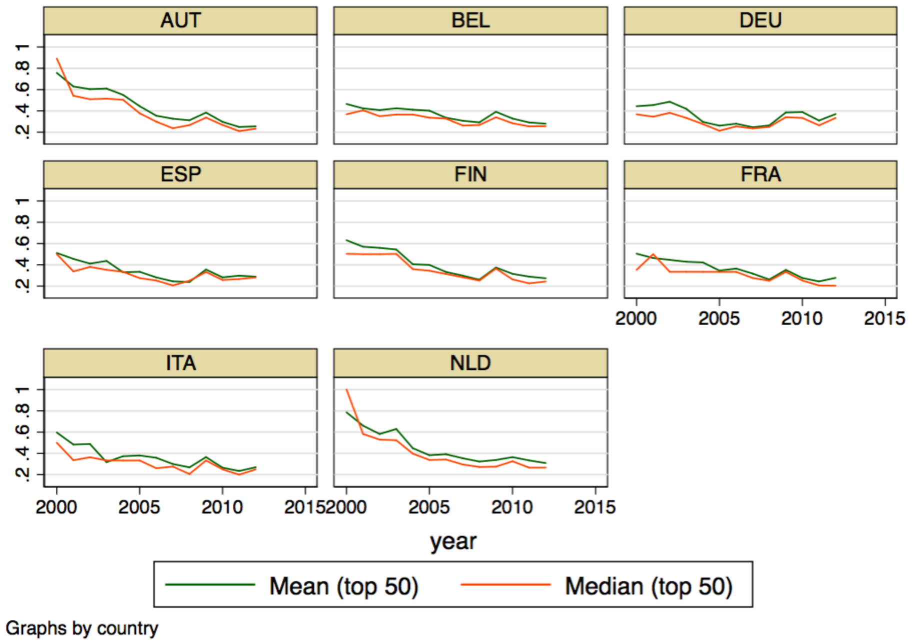
Since we use the merged vintage dataset of Kalemli-Ozcan et al. (2015), we refer to the paper for a detailed discussion on sampling and merging procedure. Here we present some details on the data. We find that even in the merged vintage dataset there are a lot of missing values for sales and total assets:

Country	Missing sales	Missing total asset
Austria	0.436	0.442
Belgium	0.472	0.000
Germany	0.320	0.442
Spain	0.016	0.000
Finland	0.031	0.015
France	0.004	0.030
Italy	0.001	0.000
Netherlands	0.879	0.129
Total	0.274	0.112

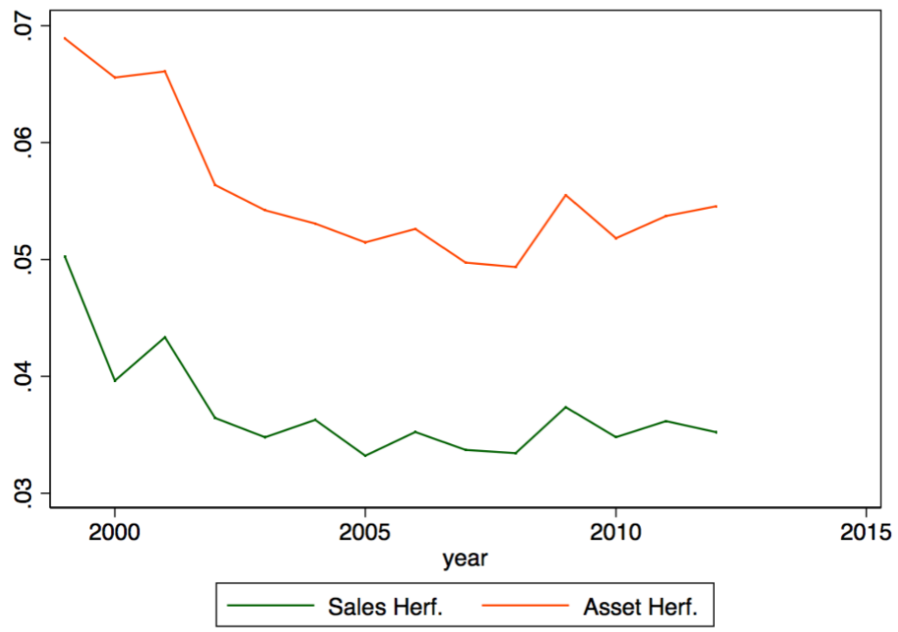
We find that the missing values can, sometimes, create a problem when computing Herfindahls using all firms. The following Figure plots the mean and median Herfindahls by country. The extremely low level of Herfindahls in Spain, Italy and France stand out. These are exactly the countries that have the fewest missing sales values.



That said, Computing Herfindahls using the top 50 firms in a given industry overcomes this problem. This is likely because data availability among larger firms tends to be of higher quality:



Moreover, because missing data patterns often differ between sales and assets (e.g., Belgium and Netherlands), we can use both measures to validate our conclusion. As shown below, both asset-based and sales-based Herfindahls appear to have decreased since 2000:



Comment on "Is there an Investment Gap in Advanced Economies?" by Robin Döttling, Germán Gutiérrez and Thomas Philippon

By Janice Eberly[86]

Abstract

Döttling, Gutiérrez and Philippon provide an empirically rich and thoughtful analysis of capital investment in Europe and the United States over the last 30 years. They confirm that investment has slowed in both regions since the early 2000s, but the explanations in the two regions differ sharply. In Europe, weakening investment is associated with weaker performance, as measured by cash flows and Tobin's q. There is no gap to explain. To the contrary, U.S. investment is lower than predicted by these fundamentals. This is partially explained by rising intangible investment, though the gap between the U.S. and Europe is narrowing over time. The gap is also correlated with rising concentration among U.S. firms, which could depress investment demand. These broad trends suggest that changes in technology and market structure may be having profound effects on production, though more analysis of causality is needed to determine policy implications.

1 Introduction

The slow economic recovery in advanced economies following the financial crisis led to some focus on apparently weak growth in investment. Subsequent research suggests however, that weak investment growth, like weak productivity growth, predates the financial crisis, though it was exacerbated by the crisis. This paper asks whether sluggish investment growth is a common feature of advanced economies in Europe and the U.S., and if so, what explains it.

The authors provide an exhaustive data collection effort to bring not only country and industry-level data to bear on the question, but also firm-level data from Europe and the U.S. While the data cannot always be completely reconciled, as the sources and intent of the data differ, the authors do an exhaustive and commendable effort to bring together a broad range of comparable data sources. I won't remark extensively on the data except where there is some concern about the interpretation of the results, but that should not underestimate the value of the data provision.

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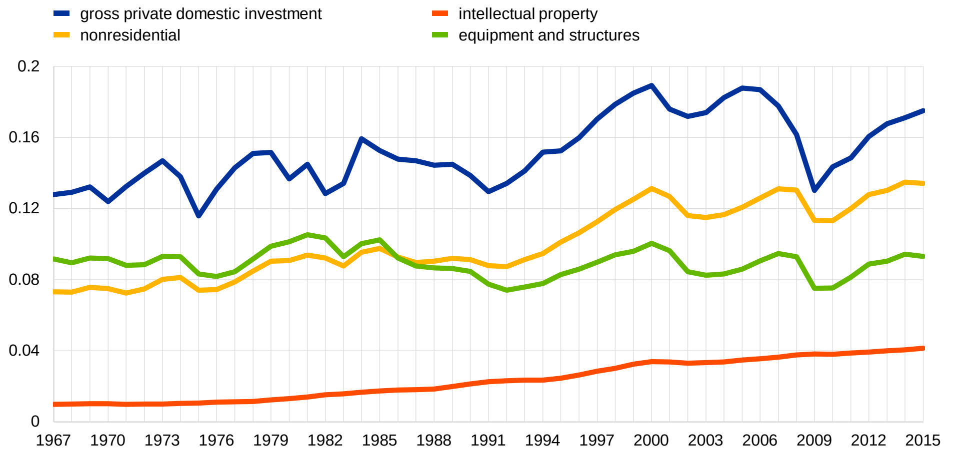
With these data, the authors first examine whether there is an investment gap in advanced economies conditional on fundamentals (cash flow and Tobin's q). The answer for Europe is "no" – weak Tobin's q and cash flow generally explain weak investment. But for the U.S., the answer is different. Not only is the answer "yes", but it is "yes" in interesting ways. There is a gap between observed investment and what we would expect based on relatively strong Tobin's q and cash flow. Moreover, that gap is correlated with interesting aspects of the economy. Getting from these interesting observations to policy, however, requires more evidence on causality, though the results are quite intriguing.

2 Investment Facts and Measurement

Döttling, Gutiérrez and Philippon show the decline in investment relative to capital in both Europe and the U.S. Figure 1 shows a similar trend in the "top line" fixed investment to GDP ratio for the U.S., which is highly cyclical, but the peaks and troughs decline over time. Given the importance of housing in the financial crisis, and the fact that our discussion focuses on corporate investment, the next line in the chart removes residential investment, and the downward trend is evident, but not dramatic. However, separating nonresidential investment into equipment and structures, versus intellectual property, helps to clarify the trends. Equipment and structures have a stronger downward trend, while intellectual property tends to rise (as a share of GDP) over time.

Chart 1

Real Investment in the United States, 1967-2015



Sources: Bureau of Economic Analysis and author's calculations

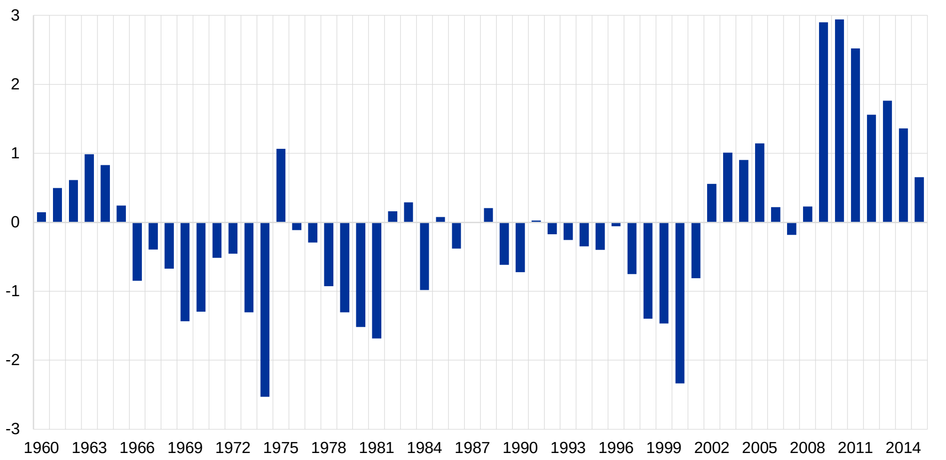
The aggregate data suggest several directions of analysis. First, there are many correlated trends, so the time series data are unlikely to clearly distinguish alternative explanations. Intellectual property and other intangibles (see below) are trending up, as is the concentration measure emphasized by Döttling, Gutiérrez and Philippon. Hence, identification is likely to require cross-section data, as the authors suggest.

Second, the composition of investment is changing over time. Intellectual property is playing a larger role, and traditional capital investment, like equipment and structures, is smaller. Moreover, equipment now also includes software investment, so even traditional investment measures have a larger intangible component. In addition, software and intellectual property may be developed internally by firms, as well as purchased. This is an example of intangible investment that would not be measured as capital investment by firms, but is conceptually part of the capital stock, even as measured in the national accounts.

Intangibles are potentially both an economic issue and a measurement issue. On measurement, if firms develop software (or intellectual property or brand value) internally, they typically expense the cost, such as wages, reducing profits. Correspondingly, firms would not measure the resulting output (software) as investment. Correctly measured, these two transactions should be offsetting, so that net business savings (business savings less investment) would be unchanged. Yet Chart 2 shows that net business savings rose dramatically in the U.S. – to all time highs. Hence, a simple explanation involving unmeasured intangible investment is unlikely to solve the "gap" puzzle. It may be reconciled by additional factors, but the effect would have to be large, since rising business savings have far outstripped comparatively weak investment.

Chart 2

U.S. Net Business Savings



Sources: U.S. national Accounts Data and authors' calculations
Notes: Figure 14, Alexander and Eberly (2017).

This leaves the question of how profitability and valuations have risen in the U.S., while investment remains weak, which is another way of stating the "gap" identified by the authors. They identify credit constraints, intangibles, and rising concentration as possible explanations. The paper dismisses credit constraints as a potential explanation based on their data, which is also consistent with the high levels of net business savings in the U.S. just discussed. My remarks will focus on the other two explanations: intangibles and concentration.

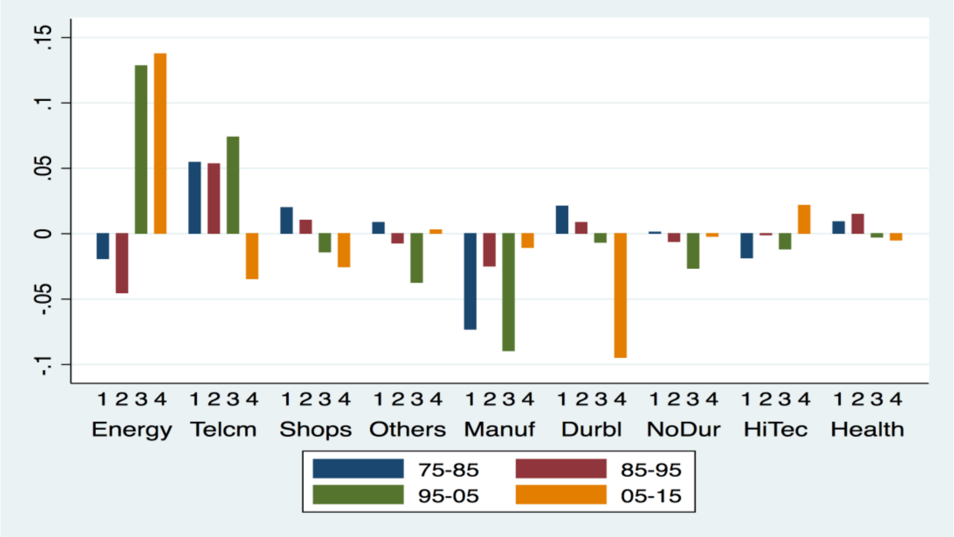
2.1 The Distribution of Investment

Gutiérrez and Philippon show that the slowdown in investment started well before the financial crisis – in the early 2000s. This is consistent with results for U.S. investment in Alexander and Eberly (2017, forthcoming) and for U.S. productivity by Fernald, Hall, Stock, and Watson (2017). This timing also coincides with changes in the labor market emphasized by Autor, Katz, and Kearney (2006, hereafter AKK), who emphasize the effects of off-shoring and automation on wages: the hollowing out of the wage structure. They suggest that middle-skill, production and routinized jobs are the most susceptible to off-shoring and automation, whereas non-routine and cognitive tasks are difficult to off-shore and/or automate. They propose that these forces have driven employment gains among lower skill, non-routine jobs, such as in health care and personal services, employment losses in middle-skill routine work of factory and clerical jobs, and employment gains among high skill, non-routine and cognitive jobs (skill-biased technical change). If these forces are powerful enough to restructure employment – in the U.S. and other advanced economies, they may affect capital as well as labor. In particular, if jobs are off-shored, the capital investment supporting them may depart as well. Automation is more complex, as it may involve greater capital investment, or a different mix of tangible capital and intangible capital, which we discuss below.

Figure 3 from Alexander and Eberly is suggestive of these forces. The figure plots the distribution of investment across industries by decades, starting in 1975 through 2015, from firm-level (Compustat) data for the U.S. Early in the sample, investment in Telecommunications grows as a share of total investment, while the declining fortunes of U.S. manufacturing are evident in consistently declining investment shares. Over time, investment in production industries continues to shrink steadily (in the middle of the chart), while investment in the energy sector increases starting in the 1990s and thereafter. Consistent with AKK's findings for labor markets, the non-tradeable sectors represent a rising share of investment, while production sectors shrink. This is consistent with the fact that energy (primarily extraction and distribution) and telecommunications (distribution) cannot be practically off-shored, so growth is reflected in rising investment (primarily structures). In contrast, there is dramatic growth in high tech valuations and profitability, consistent with the AKK employment data and skill-biased technical change. However, this growth has not generated growing fixed capital investment in high tech industries. Instead, the investment shares of Hi Tech industries on the right of the graph are roughly flat.

Chart 3

The Distribution of Investment across Industries, over Decades



Sources:Compustat data and authors' calculations
Notes:Figure 3 in Alexander and Eberly (2017)

This observation is a companion to the investment gap identified by Gutiérrez and Philippon. Overall, investment is low relative to profitability and valuations (Tobin's q) in the U.S. Moreover, the investment share of some of the most innovative and rapidly growing sectors in the U.S., high tech industries, where we might expect to see robust capital investment, is instead stagnant.

3 Potential Explanations

3.1 Intangibles

The increasing role of intangibles in investment is a potential explanation for the gap between investment and fundamentals in the U.S. Intangibles rose around the same time that investment has slowed, and have played an increasing role over time. The mechanism may be either mismeasurement of total investment, or technological change affecting capital inputs, or both.

Mismeasurement deserves special attention because intangibles are notoriously difficult to measure. Most firms do not directly report intangible investment in software development, for example, intellectual property, or brand. The Bureau of Economic Analysis (BEA) has only recently developed estimates at the aggregate level, and firms estimate the value of intangibles directly only when accounting for valuations of mergers and acquisitions. Economists have developed estimates of intangible capital by accumulating expenditures on R&D or SG&A (sales, general, and administrative), as in Döttling, Gutiérrez and Philippon. Even if all of these factors could be addressed, measuring the price indexes correctly in the presence of rapid technological change would also be very difficult.

Despite these measurement shortcomings, empirical estimates, such as those in the current paper, typically find an effect of intangibles on capital investment, suggesting that intangibles interact negatively with fixed capital investment. These results are not causal, but suggestive, and are present, even controlling, for firm and time effects. Simple regressions, including those in the current paper, consistently suggest that rising intangibles investment is correlated with a falling share of investment in fixed capital.

3.2 Concentration

My earlier comments related the decline in investment to the “hollowing out” literature in the labor market. The declining labor share in income is a related phenomenon, wherein compensation to labor input has fallen while the compensation to capital has risen. Recent work by Autor, Dorn, Katz, Patterson, and Van Reenen (2017, hereafter Autor, et al.) links the declining labor share to rising concentration in U.S. industries. They measure concentration using sales in 4-digit industries, and then average these industries to larger sectors. Their Figure 1 is indicative of their findings, which show an upward trend in concentration across a variety of industries, especially in the 1990s but continuing through the 2000s. Autor, et al. then link this increase to the declining labor share, especially in manufacturing (see their Figure 3).

Döttling, Gutiérrez and Philippon take a similar approach, using an industry concentration measure starting in 2001 for the U.S. and Europe. The results comparing the U.S. and Europe are remarkable in their contrast. There is essentially no increase in concentration evident for Europe, while the US shows the upward trend emphasized by Autor, et al. That this lines up with the difference in the investment gap for the two regions is intriguing and suggests a simple resolution of the puzzle. Perhaps rising concentration in the U.S. is associated with greater market power by U.S. firms, which drives declining marginal returns to capital. In effect, marginal q is falling further below average q, so Tobin’s q increasingly overstates the true incentive to invest in the U.S. Hence investment underperforms Tobin’s q in the U.S., but not in Europe, where there has been no such increase in market power.

This is an elegant and potentially compelling hypothesis. Before embracing policy solutions, however, the result bears some scrutiny. First, Autor, et al.’s longer time series for concentration suggests that it has been rising for decades, starting as early as the 1980s. The investment gap, on the other hand, appears in the 2000s. The effect may have been delayed, but this should be sorted out. Similarly, concentration is not a perfect measure of market power, as both critics and enforcers of competition policy are quick to point out. Sales in 4-digit industries are not necessarily a clear indicator of the markets in which firms realistically compete.

More concerning is the fact that concentration is endogenous, so we should ask what drives concentration, and whether those forces themselves result in weak investment. For example, manufacturing has been declining for decades by many metrics. The number of firms is among those metrics, so concentration may rise as firms exit or are taken over by more productive firms. This process of consolidation may be associated with lower industry investment, as successful firms grow by acquisition (reallocation of capital) rather than by new capital formation. This is entirely consistent with high Tobin's q and profitability among the surviving firms. Thus, greater concentration may be correlated with lower investment for reasons unrelated to market power.

Finally, there may be an interaction between market power and intangibles. For example, a form of intangibles recognized and measured by the BEA is brand value. By their approach, brand is a factor of production and form of capital. Alternatively, it may be a source of product differentiation and market power. Thus intangibles could be a mechanism by which market power reduces overall investment. This perspective emphasizes that market power and intangibles are not mutually exclusive explanations for the investment gap in the U.S., but are instead complementary.

4 Conclusions

Döttling, Gutiérrez and Philippon develop a rich set of data to compare investment in advanced economies. They identify some important contrasts between the U.S. and Europe, as well as some empirically interesting explanations. The gap between actual investment and what we would expect given economic performance is large in the U.S. and small in Europe. The explanation for this gap in the U.S. raises fascinating and challenging questions. The authors find evidence that part of the explanation lies with intangible capital; perhaps because of new technologies and the new forms of capital needed to implement them. This direction is also suggested by cross-section data showing that high tech industries, despite high entry, rising numbers of firms and rising valuations, nonetheless do not account for a rising share of fixed capital investment. The authors also show that weak investment is associated with rising industry concentration. This could be indicative of rising market power, so that firms have less incentive to invest and grow. However, both of these explanations require more compelling evidence that they are causal before leading to policy implications.

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INVESTMENT AND GROWTH
IN ADVANCED ECONOMIES
ECB FORUM
ON CENTRAL BANKING

Public financing of innovation: from market fixing to mission oriented market shaping[87]

By Mariana Mazzucato[88] and Gregor Semieniuk[89]

Abstract

Economic theory justifies policy when there are concrete market failures. The article shows how in the case of innovation, successful policies that have led to radical innovations have been more about market shaping and creating through direct and pervasive public financing, rather than market fixing. The paper reviews and discusses evidence for this in three key areas: (1) the presence of finance from public sources across the entire innovation chain; (2) the concept of 'mission oriented' policies that have created new technological and industrial landscapes; and (3) the entrepreneurial and lead investor role of public actors, willing and able to take on extreme risks, independent of the business cycle. We further illustrate these three characteristics for the case of clean technology, and discuss how a market-creating and shaping perspective may be useful for understanding the financing of transformative innovation needed for confronting contemporary societal challenges.

1 Introduction

Schumpeter's focus on innovation and inter-firm competition made him place finance at the centre of his analysis. He called the banker the "ephor" of the exchange economy (Schumpeter 1912, p. 74). He did not, however, look at the problem of what kind of finance is the best to serve the purposes of innovation. The works of other prominent economists such as Veblen, Keynes and Minsky have focussed instead precisely on the problem of the quality of finance. Unlike the Modigliani-Miller theorem which assumes that financial structures are inconsequential to the workings of the real economy (Modigliani and Miller, 1958), they saw the quality of finance as central to understanding the workings of capitalism. Veblen (1904), for instance, distinguished between industrial and pecuniary motives, and emphasised how the pursuit of pecuniary gains by business managers and investment bankers is often in stark opposition to technological industrial advances (Wray, 2012). Keynes too,

[87] This is a background paper for the session on Innovation, investment and productivity, ECB conference, Sintra borrowed heavily from Mazzucato, M. and Semieniuk, G. (2017) "Public financing of innovation: new questions", *Oxford Review of Economic Policy*, Volume 33 (1): 24–48 academic.oup.com, Public-financing-of-innovation-new-questions.

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highlighted how 'speculative' finance is a threat to the workings of industrial enterprises, when "the capital development of a country becomes the by-product of the activities of a casino" (Keynes, 1936, pp. 142-3). Moreover, as Minsky succinctly put it, the "dichotomy between enterprise and speculation draws attention to the financial structure as an essential element in the capital development process" (Minsky, 1992, p. 11).

So what do we know about the relationship between finance and innovation? Financial institutions are indeed central to any system of innovation because they provide access to high-risk capital for firms interested in engaging with new technologies: from IT, to nanotech and the emerging green-tech industry. Innovation is highly uncertain, has long lead times, is collective and cumulative (Lazonick and Mazzucato, 2013). These four characteristics reveal much about the kind of finance that is needed. The uncertainty means that finance must be willing to bear high risks; the long-run nature of innovation and its cumulativeness imply that the kind of finance must be patient; and the collective nature means that there is not only one type of finance that is involved – but rather different forms, from a variety of public and private sources. Thus, it can be expected that the type of finance received will affect the nature of investments made (O'Sullivan, 2004; Mazzucato, 2013b). In turn, the type of finance that is provided depends heavily on its source, whether it is the private or the public sector and the multitude of different types of public and private finance.

In this respect, recent literature has highlighted how private finance has increasingly retreated from financing productive activities (Turner, 2015) and the real economy itself has become increasingly financialised, with spending on areas such as share buybacks exceeding spending on long-run investments like human capital formation and R&D (Lazonick, 2013). Why is this happening? One of the reasons the private sector has been disinvesting in the difficult R side of R&D is its increasing short-termism. This has been caused both by corporate governance structures that prioritise quarterly returns (Kay, 2012), as well as macroeconomic conditions, like low interest rates, that make share buybacks more profitable. The pressure to maximise shareholder value (Jensen and Meckling, 1976) differs across countries depending on their 'variety of capitalism' (for example, Japan vs. the US, see Hall and Soskice, 2001), and firms within sectors often respond differently to shareholder pressures depending on their corporate governance. In telecoms, for example, Huawei and Ericsson reinvest their profits back into production, while Cisco has become increasingly financialised (Lazonick, 2015). Davies et al. (2014) and Haldane (2016) provide firm-level evidence, showing that in recent decades capital markets have become excessively focused on short-term profits, with a negative impact on the investment rate of publicly-quoted firms. Other authors have concentrated on the problems associated with short-term finance in science-based industries, which are better served by long-term finance (Pisano, 2006; Mirowski, 2011). When companies receive long-term finance, they can learn more and dare to invest in areas that will require much trial and error (Janeway, 2012). For all these reasons, the type of finance that innovators receive is not neutral and can affect both the rate and the direction of innovation.

This debate about what sort of finance is relevant for innovation is particularly significant given the importance that policymakers are attributing to innovation policy as a way to address the so-called grand societal challenges such as climate change, natural resource scarcity, ageing and improved healthcare (European Commission, 2011). As these challenges require ‘transformative’ innovation (Mazzucato, 2016), it is crucial to understand source and type of finance that might be able to initiate and sustain such a transformation. Is there enough patient finance to fund long-term investments in the real economy and in particular for such high-risk societal challenges?

To answer this question we can learn from the lessons of previous technological revolutions (e.g. IT, biotech, nanotech), where different forms of public funds had been essential in providing the high-risk and early funding (Block and Keller, 2011; Mazzucato, 2013a). Most often, such investments had a ‘mission-oriented’ nature, actively creating new industrial landscapes that served a need (man on moon, or agricultural needs) that did not exist before (Mowery, 2010; Foray et al. 2012). The green technological revolution today is witnessing a similar dynamic whereby it is mission-oriented public funds that are investing in the most capital intensive and high risk areas (Mazzucato and Semieniuk, 2016). Such investment is provided not only for the supply side (research and development) but also for the demand side: deployment and diffusion (Climate Policy Initiative, 2013).

And yet the classic market failure perspective on public investment in innovation does not justify the breadth and depth of public investments that we observed across the entire innovation chain, from basic research to applied research, early-stage financing of companies, and demand-side procurement policies (Mazzucato, 2013a). At best it can justify investments where there are clear market failures, such as the presence of positive externalities (e.g. public goods like basic research requiring public investment in basic science) and negative externalities (e.g. pollution requiring carbon taxes). But as the history of innovation shows, the great extent of public commitment that is required entails more of a market-making and market-shaping approach than a simple market fixing one (Mazzucato, 2016). Furthermore, the systems of innovation literature has also not adequately addressed the issue of the quantity and quality of public investment needed to address the market creating process.

In this paper we review evidence of market-shaping public financing of innovation, and discusses views of the state that are helpful for understanding it. Section 2 confronts market-failure arguments with the recent history of financing innovation, especially in the IT and pharmaceutical sectors in the US. It is argued that the quantity and quality of public finance for innovation cannot be explained through a standard market-fixing framework. Section 3 argues that better understanding the ‘mission-oriented’ role of the State, and the ‘Entrepreneurial State’ activities across the whole innovation chain, can provide key insights for understanding the type of finance needed for transformative innovation that addresses challenges like climate change. Here we focus on the need to understand the market-making and market-shaping, not only market fixing role of public finance. In Section 4 we substantiate this with evidence of ‘market making’ activity of public funds in the renewable energy sector. We conclude that without a market making agenda, climate change targets and the required technological revolution in energy will not take off. In Section 6 we discuss future research questions related to the use of a market making and shaping framework to guide innovation policy, and address caveats regarding the possibility also of 'government failure'.

2 Beyond fixing markets

The idea that the State is at best a fixer of markets has its roots in neoclassical economic theory, which sees competitive markets as bringing about optimal outcomes if left to themselves. This theory justifies government 'intervention' in the economy only if there are explicit market failures, which might arise from the presence of positive externalities (e.g. public goods like basic research, which require public sector spending on science), negative externalities (e.g. pollution, which require public sector taxation) and incomplete information (where the public sector may provide incubators or loan guarantees). Thus, apart from financing R&D, there is little active role for public financing of innovation. On top of this the literature on systems of innovation, have also highlighted the presence of system failures – for example the lack of linkages between science and industry – requiring the creation of new institutions enabling those linkages (Lundvall, 1992).

And yet the recent history of capitalism depicts a different story – one in which it is the State that has often been responsible for actively shaping and creating markets and systems, not just fixing them; and for creating wealth, not just redistributing it. Indeed, markets themselves are outcomes of the interactions between both public and private actors, as well as actors from the third sector and from civil society. More thinking is required to understand the role of the public sector in the market creation process itself. This is what the work on mission oriented innovation has argued (Mowery, 2010), but only indirectly. Missions are about the creation of new markets, not the fixing new ones – and yet this framework has not debunked the market fixing policy framework. Indeed, even the systems of innovation literature (Lundvall, 1992) has not fully divorced itself from a 'fixing' perspective, as the way it is often interpreted is in terms of fixing system failures (e.g. formulating the missing links between science and industry) . In her book *The Entrepreneurial State* (2013a), Mazzucato has attempted to use this work to consider the lead investment role of public agencies, taking on extreme risk in the face of uncertainty, which then generates animal spirits and investment in the private sector.

Before considering what a new framework for thinking about financing innovation might look like, we first consider key evidence to show the degree to which the market failure framework is limited in its ability to justify the depth and breadth of public activity. We focus on three key areas: (1) public investments spread across the entire innovation chain, not only key areas where positive externalities or incomplete information are present; (2) the mission oriented, hence market-making, nature of the organisations involved in the investing activity; (3) the high level of risk taking and portfolio management that an entrepreneurial State perspective entails that entails a counter- and pro-cyclical nature of public investments.

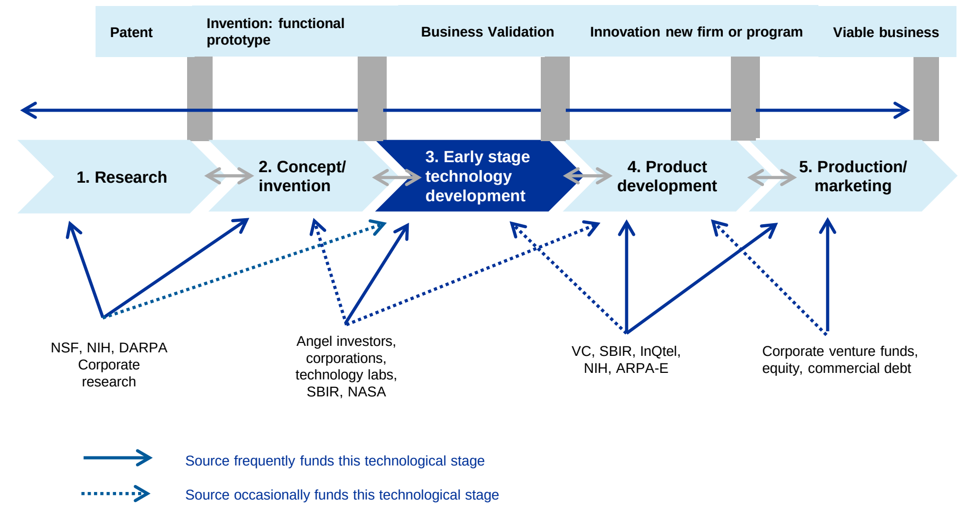
2.1 Investment along the entire innovation chain

Market failure theory justifies intervention when there are clear market failures, such as when there are positive externalities generated from 'public goods' like basic research. Yet while technological revolutions have always required publicly funded science, what is often ignored by the market-failure framework are the complementary public funds that were spent by a network of different institutions further on in the innovation process as well. In other words, the public sector has been crucial for basic research as well as for applied research, and for providing early-stage high-risk finance to innovative companies willing to invest. It was also important for the direct creation of markets through procurement policy (Edler and Georghiou, 2007) and bold demand policies that have allowed new technologies to diffuse (Perez, 2013). Thus, Perez argues that without the policies for suburbanisation, mass production would not have had the effect it did across the economy.

Chart 1 indicates (at its bottom) some of the key public agencies in the US innovation landscape, including National Institutes of Health (NIH), NASA, DARPA, Small Business Innovation Research Program, National Science Foundation (NSF) etc. that were active across the entire innovation chain. Such organisations have been 'mission driven', that is, have directed their actions based on the need to solve big problems and in the process actively created new technological landscapes, rather than just fix existing ones (Foray et al., 2012). Downstream investments included the use of procurement policy to help create markets for small companies, through the public Small Business Innovation Research (SBIR) scheme, which historically has provided more early stage high-risk finance to small and medium sized companies than private venture capital (Keller and Block, 2012), as Chart 2 shows. And guaranteed government loans are regularly used to pump prime companies, such as the $465 million guaranteed government (DoE) loan received by Tesla to produce the 'Tesla S' car.

Chart 1

Mission-Oriented Finance along entire innovation chain

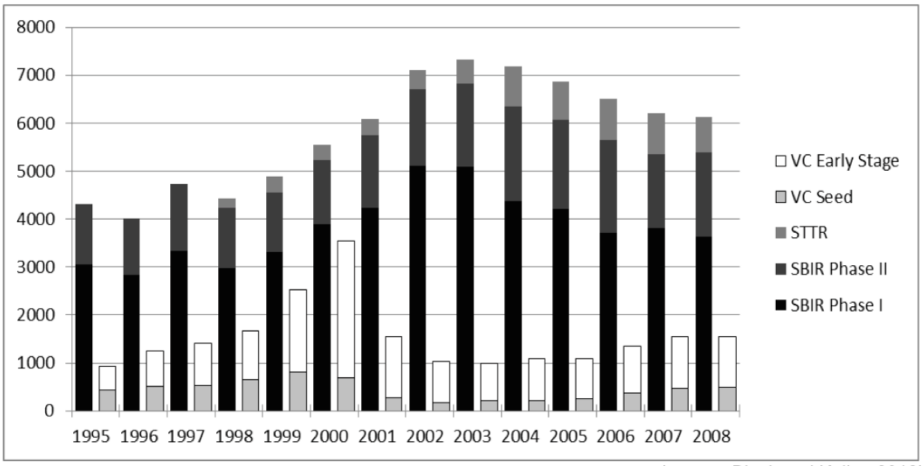


Source: Mazzucato (2013a) addition to Auerswald/Branscomb (2003).

Likewise, Compaq and Intel benefited from early-stage funding to set up the companies, not from venture capital but from the SBIR programme. While it is a common perception that it is private venture capital that funds start-ups, evidence shows that most high-growth innovative companies receive their early stage high-risk finance from public sources, such as Yozma in Israel (Breznitz and Ornston, 2013); venture funds in public banks (Mazzucato and Penna, 2016); and the SBIR programme funds in the US (Keller and Block, 2012). Venture capital entered the biotech industry mainly in the late 1980s and early 1990s, meanwhile the State had already made most large-scale investments in the 1950s and 1960s (Lazonick and Tulum, 2011; Vallas et al., 2011). In all these cases, government intervention was far from 'neutral', as the market failure framework would recommend. Instead, it deliberately targeted industries and even enterprises with a massive amount of public venture capital assistance.

Chart 2

Number of SBIR and STTR grants compared to private venture capital



Source: Keller and Block (2012).

2.2 Decentralised *mission-oriented* agencies

Crucial to this public funding was the nature of the organisations themselves: a decentralised network of strategic mission-oriented agencies (Mazzucato, 2016). The vision behind these agencies is something that is not foreseen in the market failure perspective: they do not see their job as fixing markets but as actively creating them. Mission statements can help direct public funds in ways that are more targeted than, say, simply helping all SMEs. Examples of mission statements are below:

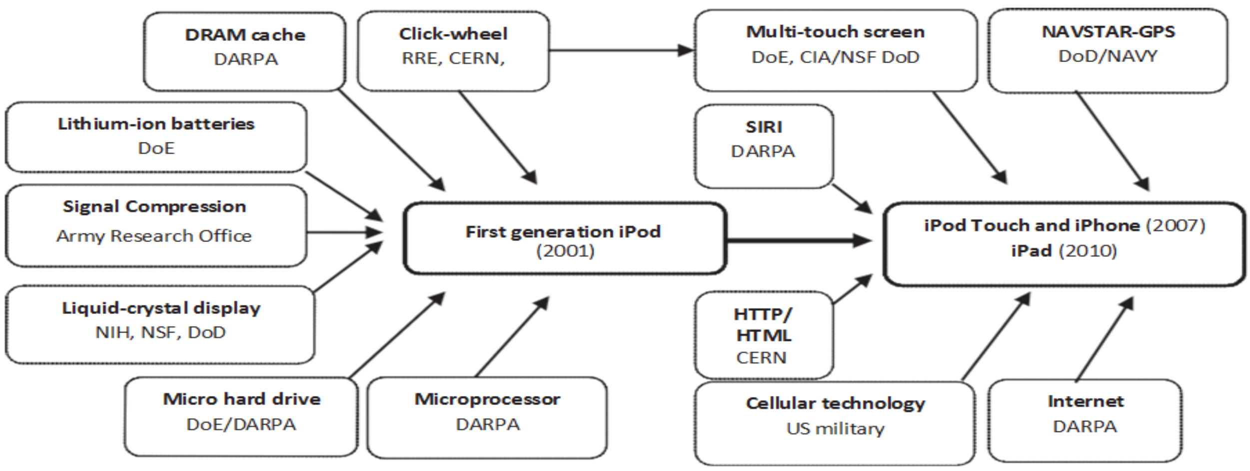
- **NASA**'s mission is to "Drive advances in science, technology, aeronautics, and space exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of Earth." (NASA 2014 Strategic Plan);

- "Creating breakthrough technologies for national security is the mission of the Defense Advanced Research Projects Agency (**DARPA**)";

- “**NIH**’s mission is to seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce illness and disability”.

In the case of IT, as Chart 3 illustrates, all of the technologies that have made Apple’s i-products (iPhone, iPad, etc.) ‘smart’ were initially funded by different mission oriented public-sector institutions: the Internet by the Defense Activated Research Projects Agency (DARPA); global positioning system (GPS) by the US Navy; touchscreen display by the Central Intelligence Agency (CIA); and the voice-activated personal assistant Siri by DARPA again (Mazzucato, 2013a). These ‘mission-oriented’ institutions (Mowery, 2010; Foray et al., 2012) actively created new industrial and technological landscapes. Missions are problem specific, using innovations in multiple sectors to achieve concrete problems – whether for military purposes, or for achieving targets in areas like energy (e.g. zero carbon emission) or health (e.g. eradicating cancer).

Chart 3
Publicly funded technology in ‘smart’ phones



Source: Mazzucato (2013a), p.109, Fig. 13.

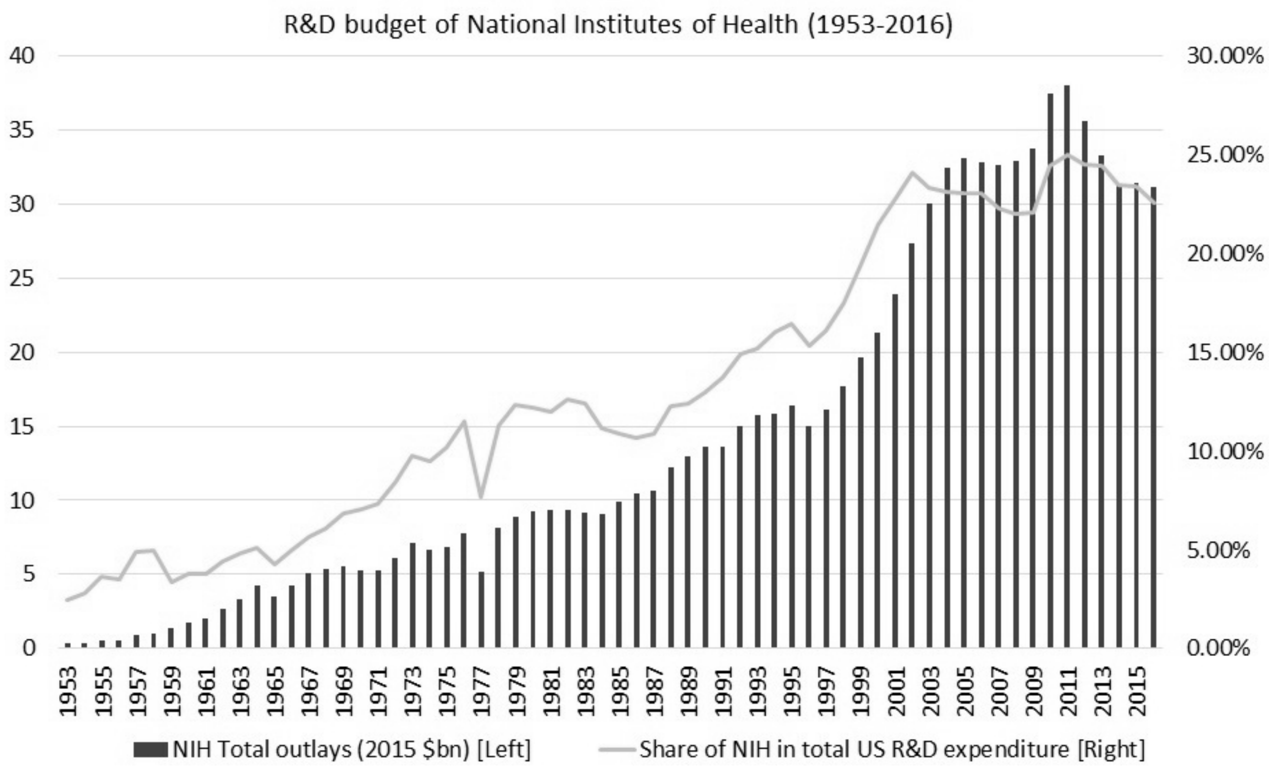
Mission-oriented agencies are potentially better able to attract top talent as it is an ‘honour’ to work for them. By actively creating new areas of growth, they are also potentially able to ‘crowd in’ business investment by increasing business expectations about where future growth opportunities might lie (Mazzucato and Penna, 2015).

2.3 Risk taking across the business cycle

Market failure theory foresees the need to also fix ‘coordination failures’ such as pro-cyclical spending in the business sector. Yet evidence shows that the mission oriented agencies have been critical across the business cycle, not only to stimulate investment during recessions. Among those agencies mentioned above, the National Institutes of Health (NIH) have spent billions on health R&D, stimulating what later became the biotechnology revolution in both periods of boom and bust. Their budget has been increased during periods of sustained economic expansion (i.e. from the mid-80s and throughout the 90s).

Chart 4

R&D budget of National Institutes of Health



Source: National Institutes of Health.
Notes: 1953-2016, in 2015 dollars

From 1936 to 2016, cumulative R&D expenditure by NIH has amounted to more than $900 billion (in 2015 dollars), and was annually above $30bn since 2004 (Chart 4). Concomitantly, research shows that around 75 percent of the most innovative drugs on the market today (the so-called ‘new molecular’ entities with priority rating) owe much of their funding to the NIH (Angell, 2004). Moreover, the share of R&D expenditure of NIH in total US federal outlays in R&D have constantly increased over the past 40 to 50 years. This suggests that the surge in absolute NIH-related R&D expenditure cannot simply be conceived as resulting from a generalised and proportional increase in total R&D expenditure by the government during downturns, or to simply level the playing field. Instead, it appears as a deliberate and targeted choice on where to direct public R&D funding.

Innovation is highly uncertain: for every success (e.g. the Internet) there are many failures. High failure rates are just as common upstream (in R&D projects) as downstream in public financing of firms. It is thus essential to better understand how portfolios are managed in mission oriented agencies is important – such as Yozma in

Israel, Sitra in Finland, or SBIR in the USA. This requires a lead investor understanding of public funds, that goes beyond the need to correct for asymmetric information. It is not a matter of lacking information, but rather the willingness to engage in big thinking, and its underlying uncertainty.

In other words, public investments in innovation have been critical for sustaining high levels of risk taking and innovation across different stages of the business cycle. More generally, this section has supplied evidence for continual, wide-spread and directed public financing of innovation – across the entire innovation chain – that a market failure framework has difficulty justifying. The market itself – in different sectors – has been an outcome of this investment (Polanyi, 1944; Evans, 1995; Mazzucato, 2016). Hence rather than accusing public actors of crowding out market actors, more research needs to be applied to building an alternative theory that acknowledges the large influence of public actors, and shines a better light on how public finance of innovation impacts the evolution of markets.

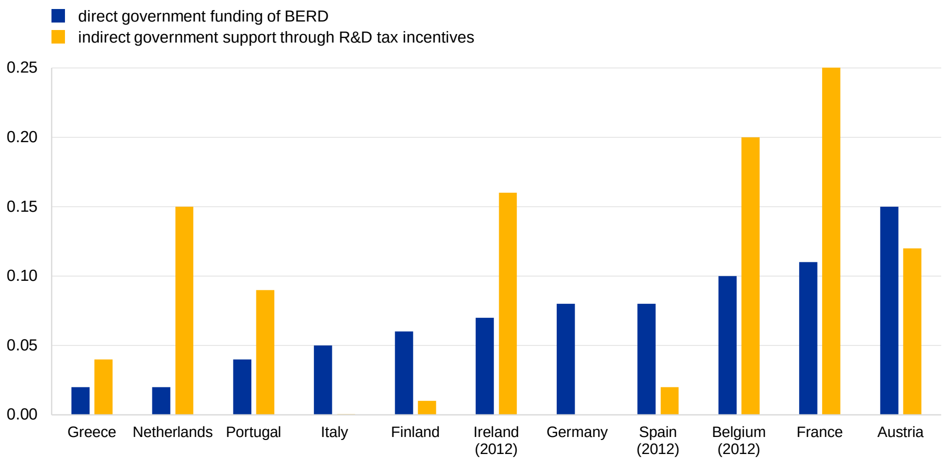
2.4 Direct vs indirect financing of innovation

Innovation can be financed directly, or indirectly through tax incentives. Direct mechanisms tend to crowd in private investment more than indirect mechanisms because they have a stronger effect on business expectations about future growth opportunities. Indeed, in *The End of Laissez-Faire* in 1926, John Maynard Keynes concluded that a crucial task for government policymaking was “to do those things which at present are not done at all”. The argument that the State should take the lead as the “investor of first resort” is all the more relevant when it comes to innovation and how to finance it. Through the theory of “liquidity preference” exposed in the *General Theory* (1936), Keynes himself suggested that in depressed economic times, monetary policy would become ineffective in stimulating private investment. Interest rates might reach low levels but the amount of total investment would not be affected if people prefer to “hoard” money, given the uncertainty over expected profitability from investing. Fiscal policy would instead be required to directly stimulate aggregate demand and arouse the “animal spirits” of businesses.

As in the case of stimulating aggregate investment through the interest rate, indirect policy measures will tend to be ineffective – if not further detrimental – to the process of generation, adoption and diffusion of technical knowledge. Innovation activities are always characterised by a high degree of uncertainty (Lazonick and Mazzucato, 2013), which public policy should aim to reduce, setting clear directions for future opportunities. A typical and straightforward way of assessing the involvement of government policy towards innovation is to look at its contribution towards financing R&D activities. As Chart 5 shows, countries in the Eurozone present different patterns of financing Business Expenditure in R&D (BERD). Relative to their GDP, the governments of Greece and Portugal spend between half and one third in direct funding of BERD compared to Austria, France and Germany. At the same time, Portugal and Greece dedicate a bigger amount of resources to tax incentives for business R&D, such as allowances and credits or in other forms of advantageous tax treatment of business R&D expenditure. However, in contexts where technological opportunities are lacking in the first place, due for instance to the lack of systemic and mission-oriented industrial and innovation policies, those incentives might be well used to avoid taxation and increasing profits, without additional investment in R&D. It is well documented – for instance in Canadian and Dutch studies (Dagenais et al, 1997; Lokshin and Mohnen, 2013) – that such indirect measures of R&D financing often do not make things happen that would not have happened anyway.

Chart 5

Direct government funding of BERD and indirect government support for BERD as a percentage of GDP (2013)



Source: Authors' elaboration on OECD data
Notes: Indirect figures unavailable for Germany.

Another example of an indirect innovation policy that does not create additionality is that of the so-called "patent box", introduced in the UK in 2013 or in Italy in 2015, following the examples of The Netherlands, Belgium and Spain. The patent box gives a tax relief on profits arising from registering a patent, which is itself a monopoly reward that seeks to defend the appropriability gain of the innovator from potential competitors. There is no reason to give an additional tax relief on that monopolistic rent: the patent entitlement is already the reward. The patent box is simply a second, additional compensation given to an activity that has already happened (Griffith, Miller & Martin, 2010). It would be much more effective to target spending on initiatives that encourage new waves of innovation, rather than the profits that are produced from past innovations.

If governments want to implement innovation policies that generate real additionality they should act as an investor of first resort, absorbing the high degree of uncertainty during early stages of innovation and possibly welcoming failures when they happens. There are nonetheless positive examples in this respect. In the case of Germany, which ranks among the highest countries in the EU in every single innovation statistics, its innovative success in recent decades have to be ascribed to the combination of a directional "High-Tech" industrial strategy (BMBF, 2014) and targeted mission-oriented programmes, such as the so-called *Energiewende* for energy transition (BWMi, 2015). These policies are directly financed by the government, either through its federal budget – State aid directed to environmental protection and energy saving has increased by almost €25 billion between 2013 and

2014, the great bulk of it through grants (European Commission, 2016) - or through the KfW, Germany's public investment bank, whose investments in energy efficiency projects in 2015 alone amounted to almost €15 billion (KfW, 2015b). On the contrary, recent industrial policy programmes such as the UK "Industrial Stragegy" or Italy's *Piano Nazionale Industria 4.0*, are still riddled with measures of R&D tax credits and other indirect incentives that most likely will not reinvigourate the "spontaneous urge to action rather than inaction", namely the endogenous "animal spirits" of the private sector to innovate.

3 An alternative theoretical framework for financing innovation

Given the historical evidence above, it is important to build a framework that can both describe past public investments that transcended fixing markets, as well as justify and evaluate future investments. Such a framework can benefit from insights from the work of Karl Polanyi, who in his seminal work, *The Great Transformation* (1944), describes the role of the State in forcing the so-called free market into existence: 'the road to the free market was opened and kept open by an enormous increase in continuous, centrally organized and controlled interventionism' (p. 144). Polanyi's perspective debunks the notion of State actions as 'interventions'. It is rather one in which markets are deeply embedded in social and political institutions (Evans, 1995), and where markets themselves are outcomes of social and political processes. Indeed, even Adam Smith's notion of the free market is amenable to this interpretation. His free market was not a naturally occurring state of nature, 'free' from government interference. For Smith the 'free market' meant a market 'free from rent', which requires much policymaking (Smith, 1776).

Polanyi analyses not only how markets form over the course of economic development. His thinking can also be applied to understanding the most modern forms of markets, and in particular those driven by innovation. As discussed above, market-failure theory provides little guidance for the more ambitious role that the State has historically played in shaping and creating markets, and not just fixing them. This requires what Schumpeter (2002 [1912], p. 97) calls dynamic not static economics. A dynamic economic framework that could be useful for justifying public policies must account for the role of the State in directing investments, creating markets and taking on risks and uncertainties as investor of first resort, not only lender of last resort.

To develop a transformational market-creating/-shaping policy approach, it is necessary to rethink the role of the State in fostering innovation-led growth. Two useful frameworks are here presented: the 'mission-oriented' innovation policy framework (Mowery, 2010; Foray et al. 2013) policies and the work of Mazzucato (2013a) on the 'Entrepreneurial State' in its leading risk-taking role.

3.1 Mission-Oriented Innovation Policy

The history of innovation policy, studied through Freeman's systems of innovation (1995), provides key insights into the limits of market-failure theory in justifying the depth and breadth of investments necessary for radical technological change to emerge. This approach emphasises system – rather than market – failures and the need to build horizontal institutions that allow new knowledge to diffuse across the entire economy (Lundvall, 1992). Innovation policy, in this historical framework, takes the shape of measures that support basic research; aim to develop and diffuse general-purpose technologies; expand certain economic sectors that are crucial for innovation; and promote infrastructural development (Freeman and Soete, 1997).

This type of broad-based innovation policy has been called 'mission-oriented' for its aim to achieve specific objectives (Ergas, 1987; Freeman, 1996). It does not merely facilitate innovation through playing field-levelling horizontal policies that prescribe no direction. On the contrary, such policies by definition give explicit technological and sectoral directions to achieve the 'mission'.

Examples of such direction-setting policies abound, including different technology policy initiatives in the US (Chiang, 1991; Mowery et al., 2010), France (Foray, 2003), the UK (Mowery et al., 2010) and Germany (Cantner and Pyka, 2001). These policies were implemented by mission-oriented agencies and policy programmes: military R&D programmes (Mowery, 2010); the National Institutes of Health (NIH) (Sampat, 2012); grand missions of agricultural innovation (Wright, 2012); and energy (Anadón, 2012). In such cases, it was the organisation that had to make choices on what to fund: tilting the playing field rather than 'leveling it' (Mazzucato and Perez, 2015). Thus the 'picking winner' problem, which continues to dominate the industrial policy debate, is a static one that creates a false dichotomy: what is crucial is not whether choices must be made, but how 'intelligent' can the picking of 'directions' be performed.

However, the literature has not integrated empirical insights to provide a full-fledged theory. Consequently, studies have resulted in ad-hoc theoretical understandings and policy advice on how to manage mission-oriented initiatives, without tackling the key justifications for mission-oriented finance that contrast those of market failure. In a market failure framework, ex-ante analysis aims to estimate benefits and costs (including those associated with government failures) while ex-post analysis seeks to verify whether the estimates were correct and the market failure successfully addressed. Instead, a mission-oriented framework requires continuous and dynamic monitoring and evaluation throughout the innovation policy process. In its most general form, the mission-oriented framework differentiates between public policies that target the development of specific technologies in line with State-defined goals ('missions') and those that aim at the institutional development of a system of innovation (Ergas, 1987; Cantner and Pyka, 2001). The State must therefore be able to learn from past experiences in mission-oriented innovation policy.

Systemic mission-oriented policies must be based on a sound and clear diagnosis and prognosis (foresight). This not only requires the identification of missing links, failures and bottlenecks – the weaknesses or challenges of a national system of innovation – but also the recognition of the system's strengths. Foresight is necessary in order to scrutinise future opportunities and also identify how strengths may be used to overcome weaknesses. This diagnosis should be used in devising concrete strategies, new institutions and new linkages in the innovation system (Mazzucato, 2016). It may also be necessary to 'tilt' the playing field in the direction of the mission being pursued rather than 'leveling' it through such means as technologically neutral policies (Mazzucato and Perez, 2015).

Mission-oriented policies can therefore be defined as systemic public policies that draw on frontier knowledge to attain specific goals or "big science deployed to meet big problems" (Ergas, 1987, p. 53). The archetypical historical mission is NASA's putting man on the moon. Contemporary missions aim to address broader challenges that require long-term commitment to the development of many technological solutions (Foray et al. 2012) and "a continuing high rate of technical change and a set of institutional changes" (Freeman, 1996, p. 34). The current active role of the public sector in tackling renewable energy investments can be seen as a new mission in relation to the green economy (Mazzucato and Penna, 2015b). Other new missions include addressing such 'grand societal challenges' as the ageing/demographic crisis, inequality, and youth unemployment (European Commission, 2011). In fact, these challenges – which can be environmental, demographic, economic or social – have entered innovation policy agendas as key justifications for action, providing strategic direction for funding policies and innovation efforts.

3.2 The Entrepreneurial State: The State as Lead Risk-Taker and Investor in the Economy

Alternative approaches to innovation policy, such as those described above, have questioned particular aspects of the economic dynamics embodied in neoclassical theory. However, they have not disputed the underlying assumption of business being the only risk-taker. The Entrepreneurial State agenda has sought to challenge the notion of the entrepreneur being embodied in private business, and policy-making being an activity outside of the entrepreneurial process (Mazzucato, 2013a). This perspective builds on studies in industry dynamics that have documented a weak relationship between entry of new firms into industries and the current levels of profits in those industries (Vivarelli, 2013). Firm entry appears to be driven by expectations about future growth opportunities, even when such expectations are overly optimistic (Dosi and Lovallo, 1998). Business tends to enter new sectors only after the high risk and uncertainty has been absorbed by the public sector, especially in areas of high capital intensity. As described in the previous section, this has been the case with the IT revolution (Block and Keller, 2011), the biotechnology industry (Lazonick and Tulum, 2011), nanotechnology (Motoyama et al., 2011), and for the emerging clean-tech sector (Mazzucato and Penna, 2014). Moreover, private venture capital funds have focused on financing firms mid-stage, which had previously received early-stage financing by public programmes, like the SBIR programmes (Keller and Block, 2012). While the literature has described such dynamics simply in terms of 'crowding in,' this ignores the direct risk-taking that such public activity entails, and hence the occasional failures that will inevitably result. In innovation policy the State not only 'crowds in' business investment but also 'dynamises it in', creating the vision, the mission and the plan.

An Entrepreneurial State does not only 'de-risk', but envisages the risk space and operates boldly and effectively within it (Mazzucato, 2013a). Unlike in theory of technology adoption of `developing economy, where the technology already exists elsewhere, an Entrepreneurial State does not foresee what the details of the innovation are, but it knows a general area that is ripe for development, or where pushing the boundaries of knowledge are desirable. The State welcomes and engages with Knightian uncertainty for the exploration and production of new products which lead to economic growth. The State has been 'entrepreneurial' when it has taken the lead by formulating a vision of a new area (for example the Internet or the genetic sequence). Then public financing of innovation comprises investing in the earliest-stage research and development; creating and funding networks that bring together business, academia and finance; funding high-risk ventures; and investing in high risk demonstration and deployment.

In sum, a theoretical framework of public financing of innovation starting from these preconceptions would emphasise the influence that public institutions take on the course of transformative innovation and their risky active involvement in financing of that innovation along the innovation chain. We next illustrate this with reference to a current societal challenge.

4 The Green Challenge

The insights about the market-shaping and creating role of public actors take on a new importance for meeting today's societal challenges (European Commission, 2011). We consider the climate change challenge which is widely seen as requiring not only a transformation of the energy system but also such transformation on a short time scale, and on which leading climate scientists and economists are currently reaffirming that not enough is done and not fast enough (Guardian 2016a, Guardian 2016b). Not enough progress is made in replacing the greenhouse gas emitting fossil fuels with a renewable power supply instead, and one bottleneck is the finance for renewable energy innovation.

Innovation in renewable energy has been especially difficult to finance for private actors because of the competition from incumbent fossil fuels. Profits have been dependent on public subsidies that ensure temporary competitiveness. With those subsidies in the form of feed-in tariffs, tax breaks and power purchase agreements, investment in the renewable energy sector, along the innovation chain from R&D over piloting and demonstration to deployment, stood at USD 285 billion in 2015 and has been rising by less than a percent annually since 2011 (UNEP & Bloomberg 2016, p.12). In contrast with this slow growth, the International Renewable Energy Agency (IRENA) estimates that a 9% compound annual growth rate in investment over the next 15 years is required to keep global warming to two degree Celsius temperature rise (IRENA, 2016, p.121)[90].

IRENA, like others, does not specify the sources of the historical or future finance for the renewable energy sector. However, the report suggests that policymakers should play an `enabling' role and `correct for market distortions to create a level playing field' (IRENA, 2016, p.20), which reflects the report's market failure lens. In fact, from the market failure perspective, the damages from climate change are an externality of energy production, hence require a correction of the externality, while innovation requires correcting the positive externality of knowledge-spillovers. Hence, carbon taxes and R&D spending are recommended (Newell, 2010, Fisher et al., 2013). But existing public sector policies fail to tax carbon, not least due to the difficulty of agreeing on one internationally, and subsidies have been employed instead. Hence, the main conclusion that a market failure perspective can draw is that existing policies – besides R&D support – are inefficient, and should instead focus on a carbon tax and small interventions to start the "private innovation machine" (Veugelers, 2012).

This approach, however, overlooks what the public sector in fact does, besides giving subsidies in the market for electricity producers. The public sector is much more active in directly financing renewable energy innovation, creating markets and, in the process, taking on high risks. We go through the same set of three areas of public activity as in section 3, and highlight how in each of these, some public actors' behavior is characteristic of a market-shaping role of the public sector.

4.1 Entire Innovation Chain

First of all, public actors in renewable energy innovation are active along the innovation chain. Government agencies are involved in R&D with around fifty percent of renewable energy sector R&D spending originating in the public sector according to the Bloomberg New Energy Finance (BNEF) estimates (UNEP, 2016), including such institutions as the recently created 32 Energy Frontier Research Centers (EFRCs) in the US that are charged to deliver 'use-inspired' basic research for renewable energy (DoE, 2016, see also Anadon, 2012). But public actors are distributed and highly active further along the chain: more applied research and development takes place in such diverse settings as the German Fraunhofer Institutes (e.g. on Solar Energy Systems), or the State-owned company development funded by the Chinese Ministry of Science and Technology's '863' program (Kempener et al., 2010, p.37). Moreover, several publicly-owned agencies are engaged in financing the commercialisation of technologies through providing venture capital: the Sustainable Development Technology Canada alone spent USD 100 million (at current exchange rates) in venture funding (SDTC, 2016), which represents some 7% of global private venture capital funding in 2015 (which stood at 1.3 billion). In 2014, the US Advanced Research Project Agency-Energy (ARPA-E)

[90] IRENA's and UNEP's numbers are slightly different as the former includes investment in large hydro (dams above 50MW capacity) and industry and building efficiency, which the latter excludes.

single-handedly funded commercialization-oriented projects to the tune of USD 188 million, or almost 20 percent of that year's private venture capital spending (ARPA-E, 2015). The Chinese State Council's Innovation fund supported one thousand energy efficiency and renewable energy ventures with RMB 1 billion already between 1999 and 2002 (Cherni, 2007, p.3619) and the Global Energy Efficiency and Renewable Energy Fund (GEEREF) is a publicly-run fund-of-funds with EUR 112 million in Norwegian and German government funds, and advised by the European Investment Bank, that leverages additional private funds and invests in renewable energy private equity (GEREEF 2016). Government activity is also wide-spread at the demonstration level of new technologies; a recent study of demonstration projects (first of a kind) in concentrating solar power, wind power and biofuels find that the median public share of funds financing those projects is above 50 percent (Nemet et al., 2016).

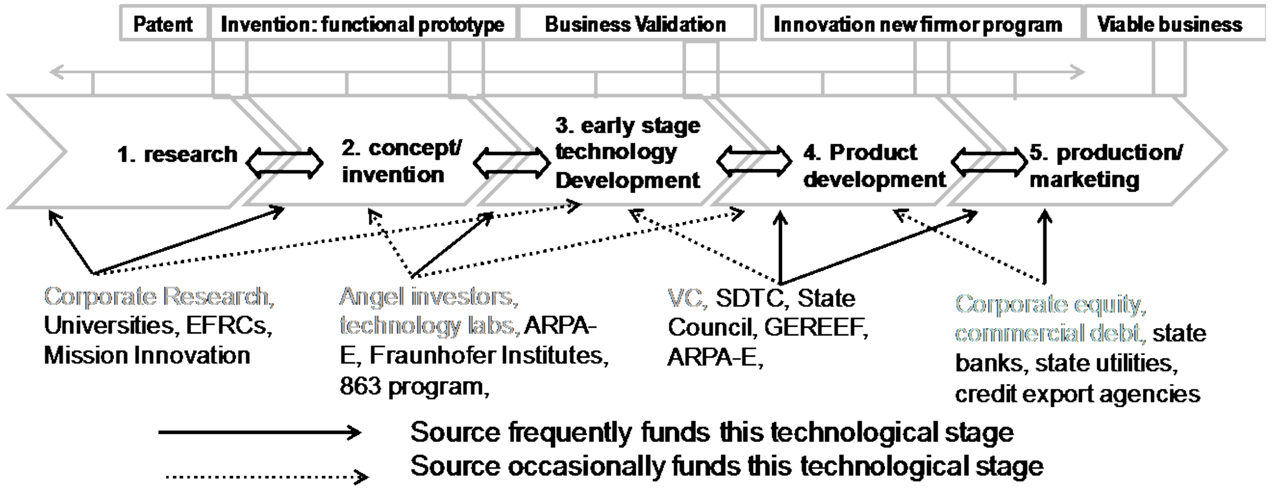
At the subsequent market-creation and deployment stage, another variety of public actors are active, ranging from government agencies and investment funds, through tremendous amounts invested by State banks, to State-owned utilities, which have both pioneered European offshore wind farm deployment (Mazzucato and Semieniuk, 2016). State-owned utilities are also behind China's rise to by far the biggest capacity of wind energy installed, as much as the whole of Europe at the end of 2015 (GWEC, 2016). In fact, at the deployment stage, publicly controlled organisations (where the public has at least a 51% share for stock-market listed organization), are now responsible for almost half of global asset finance for utility scale power plants (Mazzucato and Semieniuk, 2016). For smaller capacity, public actors provide important demand side finance such as subsidies for rooftop photovoltaic cells and individual wind turbines in Germany by the German development bank, KfW (KfW, 2015a), and also large-scale solar and hydro power plants in China by its Ministry of Finance (Lo, 2014).

Finally, this public support along the chain is completed with finance from the world's export credit agencies, which 31 countries maintain (OECD, 2016), that guarantee paybacks for national champions, when they invest abroad in risky renewable energy projects. For instance, the Danish export credit agency has sponsored wind farm development to the tune of circa USD 1.5 billion in each of 2013-2016, which insures national developers against risk by guaranteeing their repayment, which in the Danish case is, among others, the national champion Vestas, one of the world's largest wind turbine manufacturer (EKF, 2016). Chart 6 summarizes the discussion, by replacing the public actors form other sectors, showed above in Chart 2, with those specific to renewable energy innovation finance.

The data also show that this variety of public actors is not neutral but gives directions to innovation. Public actors invest in portfolios that favour one or another technology. Chart 7 shows the portfolios of asset finance for deployment invested by four different types of public actors, aggregated over individual organisations within each type[91]. The portfolios are constructed by finding the share of each actor type's total renewable energy finance that it invests in a particular technology. The shares are taken over two periods: 2004-2008, and 2009-2014. Clearly, the different types of actors held widely differing portfolios. In the aggregate, government agencies invested in a relatively balanced portfolio across technologies – governments have not picked one winner technology, but supported innovation across a suite of alternatives within renewable energy[92]. State banks, on the other hand, concentrated more than half of their investments in only two technologies in both periods. However, State banks are in turn more diversified than publicly owned utilities, which, outside China, targeted the financing of wind energy, and especially offshore wind investments after 2008. This distinguishes them not only from other public actors but also from privately owned utilities whose share of investments in offshore is lower than that for State banks (they invest heavily in less risky onshore wind). We have separated out Chinese State-owned utilities, which are the main vehicle for Chinese renewable energy expansion and are the main driver behind China's rise to the number one in terms of installed wind capacity. While the review of organizations was selective, it emerges that in countries with a strong renewable energy, public organisations were active along the innovation chain, which is typical of the market-shaping behaviour of the public actors we discussed above.

Chart 6

Mission-Oriented Finance along entire innovation chain in the renewable energy sector

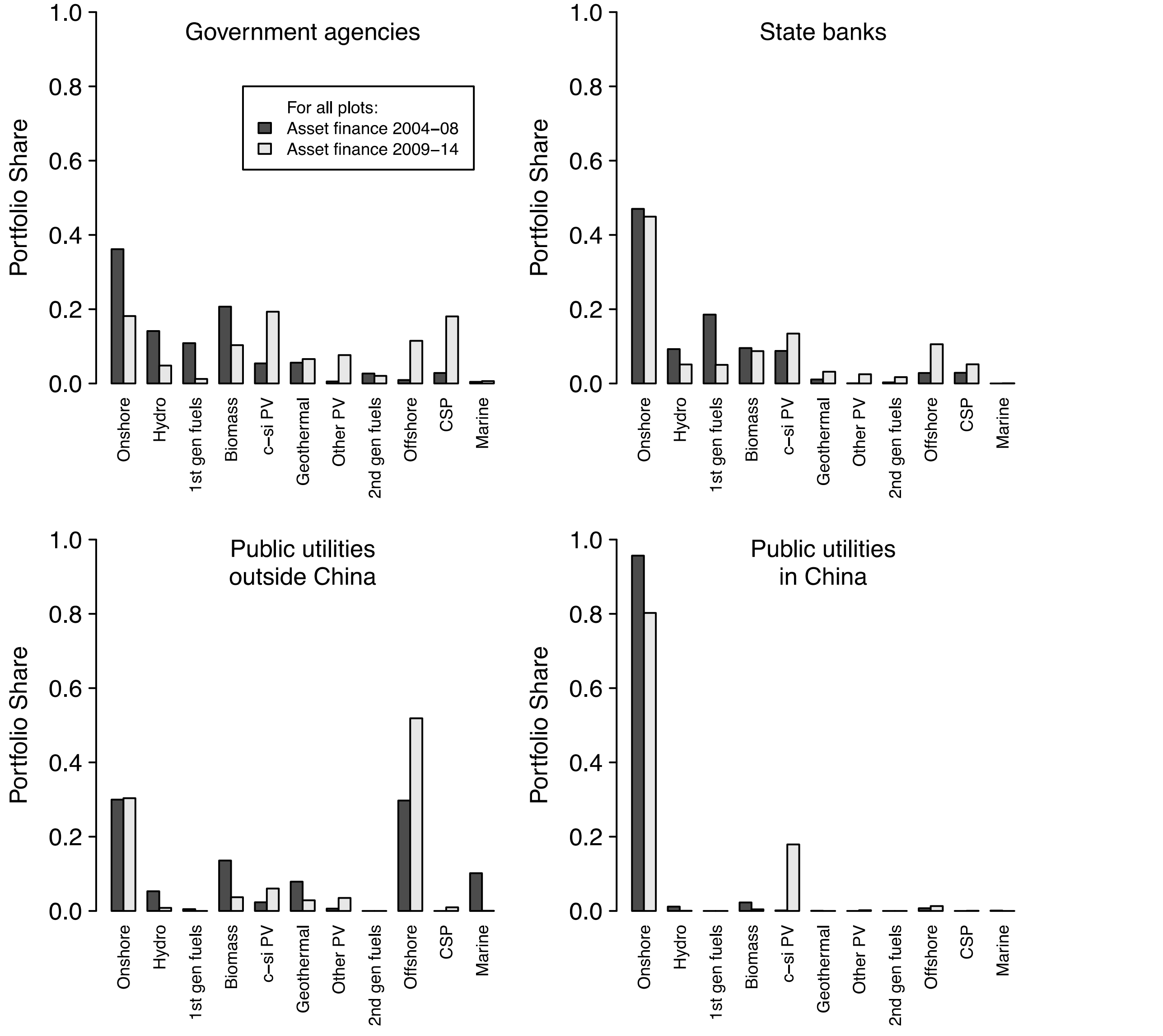


91 The data are based on our research in a companion piece (Mazzucato and Semieniuk, 2016), where we merge a deal-by-deal asset finance dataset from BNEF for the period 2004-2014 with organization indicators to identify which organisations invest in which deals. For corporations, we labelled those as public where the public sector owned at least a 51% of the shares. Based on the organization identifiers, we distinguished whether the public organisation is a government agency or research institute, a public financial institution, a publicly owned utility, or another state-owned company.

92 Of course, government agencies also heavily fund nuclear power and the US Department of Energy was funding and carrying out the innovations leading to the shale-gas technology (Trembath et al., 2012).

Chart 7

Portfolios of four types of public actor



Source: Data sources are explained in Mazzucato and Semieniuk (2016).

Notes: The share of the portfolio invested in each of 11 technologies is on the y-axis. The dark bars show the share of investment in the period 2004-2008, the light bars the share of investment in the period 2009-2014 that go to a particular technology. CSP stands for 'concentrating solar power', PV stands for photovoltaics. Marine refers to energy gained from the ocean, whether through wave or tidal energy.

4.2 Decentralised network of mission-oriented agencies

Many of the reviewed public actors are also mission oriented. Innovation in the energy sector has historically been driven by missions. In the 1970s, the mission was to boost national security by reducing dependence on the then expensive crude oil from OPEC countries. Contemporary innovation is justified by multiple missions (Anadon, 2012), but the most visible issue is that of climate change, with the mission being to limit global warming to two or preferably 1.5 degree Celsius (United Nations 2015, p. 2). Befittingly, at the Paris Conference of the Parties on climate change in

2015, twenty governments unveiled `Mission Innovation', and set themselves the goal to double their national R&D spending on clean energy over the next five years. As with previous missions, these investments are not justified by correcting a market failure but by achieving a target. In this specific case: the halting of global warming. As with previous missions also, the public sector here also seeks to draw in private sector investments, and a simultaneously launched 'Breakthrough Coalition' has 28 investor members that represent private sector leadership in key economic sectors (Mission Innovation, 2016).

But crucially, the mission orientation goes beyond R&D agencies. Thus the ARPA-E mission is to catalyse the development of transformational, high-impact energy technologies. The mission of the German KfW Group is to support change and encourage forward-looking ideas – in Germany, Europe and throughout the world. And the German Fraunhofer Institutes put it succinctly: "We are creative. We shape technology. We design products. We improve methods and techniques. We open up new vistas. In short, we forge the future" (Fraunhofer Institutes, 2016). In Germany, moreover, the 'Energiewende', the project to base the German energy supply largely on renewable energy sources, has seen the government introducing legislation favoring the mission of an energy transformation since 1990s (Hake et al., 2016). The Renewable Energy Law (EEG) states in its 2017 version that its aim is to develop a sustainable energy supply to protect climate and environment, and stipulates an 80% share of electricity from renewable energy by 2050, and 40-45 percent in 2025 (EEG, 2016, §1). Clearly, the organisations setting out these missions are active beyond the R&D ambit.

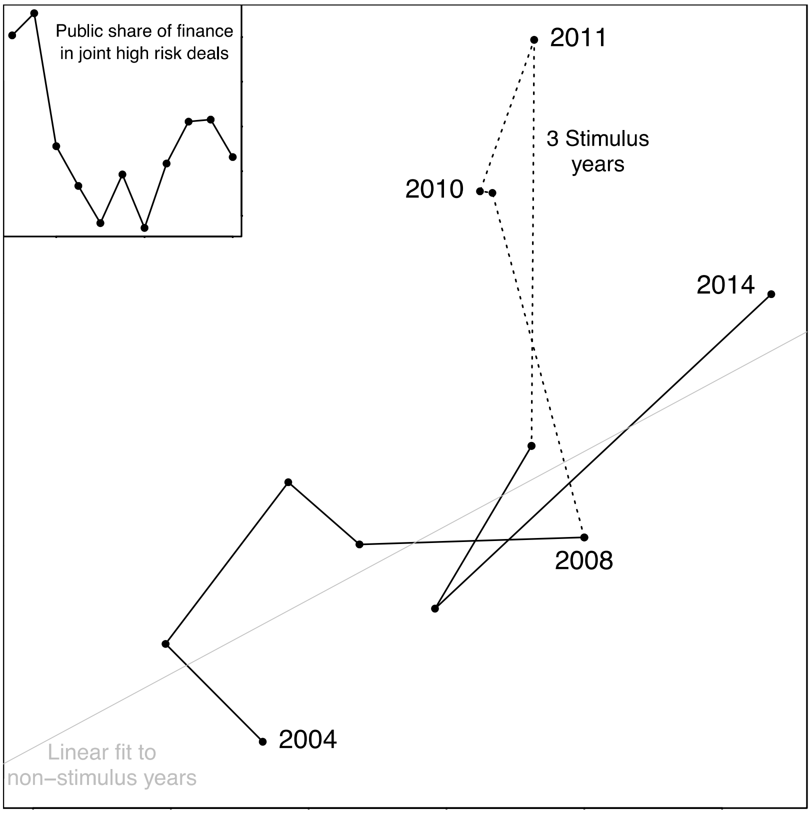
Agencies in the energy sector have also been able to attract top talent. The US Department of Energy was led by Nobel Prize winning physicist, Stephen Chu (2009-2013), now replaced by another MIT physicist, Ernest Moniz, and ARPA-E founding director, Arun Majumdar (2009-2012) is a leading engineer in thermoelectric materials. In sum, a slate of the most influential public institutions funding renewable energy research do not understand themselves as fixing market or system failures – they see themselves as pushing new and exciting horizons.

4.3 Risk taking and portfolio management

Lastly, there is also evidence in the renewable energy sector and clean tech more general, for public actors leading in risk taking across the business cycle. The technologies listed in Chart 7 above are ordered according to an increasing degree of riskiness from left to right. Thus, publicly owned utilities take on considerable risk by investing a large share of their portfolio in offshore wind. In a companion piece (Mazzucato and Semieniuk 2016), we have not only justified this risk ordering, which is ordinal and suggests that onshore wind is no more risky than any other technology investment on average but does not attempt to quantify the amount of risk taken. We have also shown that with this measure public actors hold on average a much riskier portfolio than private actors in asset finance, at least when excluding the Chinese utilities charged with onshore wind diffusion. Here, we push this research one step further and analyse how high-taking by private actors is correlated with co-investment by public actors. We single out investments into high-risk areas only.[93]

Chart 8

Annual share of high-risk private renewable energy investments involving a public financing partner (x axis) vs the annual share of private funds invested into high-risk assets (y axis)



Source: Data sources are explained in Mazzucato and Semieniuk (2016).
Notes: Edges connect subsequent years. The dotted lines indicate years with significant grant and loan guarantee support as part of post-crisis government stimuli, that imply indirect public support to high risk deals carried out exclusively with private funds.

Chart 8 correlates the private investment into high risk assets with the participation of public actors in private high-risk finance. It plots the share of total private funds invested in high-risk assets in any single year against the share of these high-risk funds that are invested into an asset in which at least one public actor is also investing. In 2004, only about 1 percent of public funds went into high-risk projects, and of these, only 18 percent had a public co-investor. Both shares increased over time, so much so that a decade later in 2014, the share of high-risk projects co-funded by a public organisation stood at above 50 percent, while around 10 percent

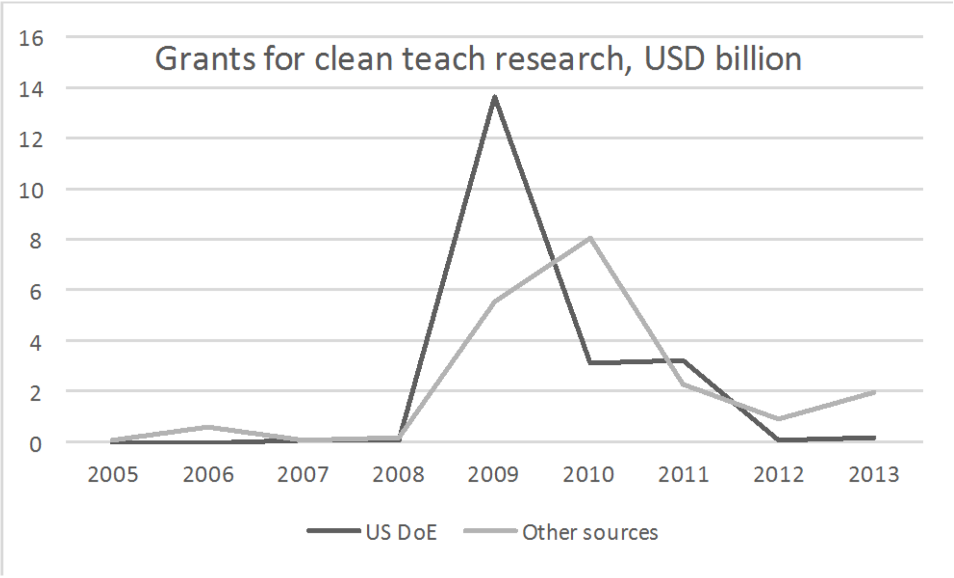
93 High risk technologies are marine energy investments, concentrating solar power, offshore wind, concentrator PV, 2nd generation biofuels, thin film PV before 2011, and c-si PV before 2008. Financing of all other technologies shown on the x-axis of Chart 8 is excluded.

of private funds went towards high-risk investments. The correlation is high (indicated by the grey linear fit), when one excludes three exceptional years – 2009 through 2011 – during which massive Keynesian stabilisation programmes kicked in, inundating markets with grants and loan guarantees. That coincided with private actors financing more risky projects with private funds only (but backed by public guarantees). From this time hails, for instance, the largest concentrating solar power plant in the Ivanpah powerplant in the US, was financed by private investors, but backed by a USD 1.6 billion loan guarantee from the US Department of Energy. The inset shows moreover, that when public actors have participated in high risk deals, they have tended to finance on average between 30 and 50 percent of the deal's volume. These statistics show that as more public actors were stepping forward finance assets, the private side became more willing to invest in the higher-risk deployment. While causality cannot be attributed, the strong positive correlation between public participation and private risk-appetite suggests that the public sector's appetite for high-risk investments was important for a significant share of deployment of those technologies that have farthest to go in terms of innovation through learning by doing.

The exceptional measures taken in 2009-2011 by governments indicate that in the energy sector, over the last business cycle, public financing was significantly driven by a coordination failure logic. Chart 9 shows clearly how the grants for renewable energy research, development and demonstration given out by the US Department of Energy (DoE) and all other grant-giving organisations spiked in those three years and dropped back almost to pre-crisis levels. A similar, albeit less pronounced pattern can be detected in investment behaviour of the big development banks – China Development Bank, KfW, and European Investment Bank. However, while declining, these banks have kept their investment at a much higher level than pre-financial crisis. Similarly, while US institution such as the EFRCs and ARPA-E were initially funded with stimulus money (Anadon, 2012), their annual funds have to date been maintained and the EFRCs even expanded in their numbers. At the same time, of course, the world economy is widely seen to remain in `secular stagnation' (Summers, 2016). It remains to be seen how public funding for renewables will be impacted if and when a business cycle boom sets in.

Chart 9

Annual total of grants given for clean energy research, development and demonstration



Source: Data sources are explained in Mazzucato and Semieniuk (2016).

In sum, the patterns we see in public financing for innovation in renewable energy, and clean tech more generally, are very far removed from the indirect policies recommended by a market-failure approach. A market shaping perspective that sees the state as entrepreneurial and risk taking, and distinguishes public actors with missions highlights these patterns. In spite of these massive interventions, the grand challenge to keep temperature rises to a modest level suggests that even the existing activities have been insufficient to mobilize the finance that is forecast as needed for achieving the mission of limiting global warming. The market-creating and shaping perspective leads to the conclusion that even more active public sector involvement in financing innovation is needed realized the 9% compound annual growth rate in investment, that IRENA estimates is needed over the next 15 years.

It is of course possible to argue that the public financing stymied as opposed to boosted overall financing, and we return to this caveat in our concluding discussion. Yet the evidence also from earlier transformative innovations, the problem that markets first have to be created before they can be corrected, and the seriousness of this and other grand challenges should caution against foregone conclusions. It seems risky not to explore the possibility that public actors that help direct innovation to certain mission-determined outcomes through massive financing of innovation may be an important driver of the transformation of how we produce energy.

5 Conclusion

In this article we have focused on the strategic role of public financing of innovation and the way it can shape and create markets. We have looked at 3 key features of this process: (1) investing along the entire innovation chain, not only in classic public good areas; (2) the mission oriented nature of the agencies involved, and (3) their lead risk taking role, independent of the business cycle. We have argued that looking at these three features of the system help to see the limits of the traditional market failure framework. We then applied this perspective to the emerging clean technology sector, as an example of transformative innovation needed to confront a societal challenge.

The market-shaping approach suggests that public financing must be proactive and bold, creating directions, and transcending the role envisaged by market or also system fixing approaches. This is even more important for contemporary “societal challenges” where the need for transformative innovation is particularly pressing. For the challenge to mitigate climate change, if the recent international agreements to fight climate change are to have effect, it is important for public organisations financing innovation to be mission-oriented and entrepreneurial. We have shown that public actors are active; yet given the estimated need for investment in this sector, this is not enough. To experience a full blown clean energy revolution, the lessons from the IT revolutionary are clear: the visible public hand is required; it must be distributed across the whole innovation chain through different actors, and justifications for the investments cannot be limited to periods with low interest rates. Even if the world was experiencing high growth, it would not be enough for tax incentives to incentivize green investments. They would need to be crowded in by public funding, simply because there is as yet no market that can work efficiently with private actors at its centre.

Two caveats to these statements are in order. First, there is no automatism whereby public involvement in financing innovation leads to superior outcomes; what we have argued against here is the assumption that public sector financing is systematically inferior to that by private actors. While the examples above focus on public investments that have led to important successes (e.g. the Internet, GPS, shale gas, blockbuster drugs), there are also government investments that end in failure. These include investments in products like the Concorde aircraft, which ultimately failed commercially; in the discovery of new drugs (of which most attempts fail); or the provision of guaranteed loans to companies which then might go bankrupt. A recent example of the latter includes the guaranteed loan of $528 million provided by the US Department of Energy to the company Solyndra for the production of solar cells. This was followed by the company’s bankruptcy when the price of silicon chips fell dramatically, leaving the taxpayer to pick up the bill (Wood, 2012). As stressed above, however, any venture capitalist will argue that attempts to innovate require exploring new and difficult paths, and that occasional failure is part of that journey. Innovation is intrinsically uncertain (Dosi and Egidi, 1991) and results in failures from time to time. This trial-and-error process, in which tolerance of failure is also the road to success, is accepted in the private sector. Failure of government investments, on the contrary, is regarded as a sign of incompetence (The Economist, 2010). If the government acts as lead risk taker, then it should be accepted that there are failures, as long as there are successes. It is important then, not to categorically dismiss public financing because some of the projects fail, but to ask what are well-designed policies for public financing of innovation. Part of the problem is that the focus on market failure has led to relatively little research and insight on ‘good practice’, and we see here an important area of research to be advanced.

A second caveat regards the motivations behind public sector financing. Public choice theory and related new public management theory have highlighted the problems associated with government failure arising from rent seeking, whereby public officials are captured by vested private interests (Tullock et al., 2002). Rents arise when value is extracted through special privileges (Krueger, 1974), and when a company or individual grabs a large share of wealth that would have been produced without their input (Stiglitz, 2012 p. 32). Then financing for innovation could go to those special interests that are not the best innovators but those with the best connections to the public funding agencies. Our lens, far from denying this problem, sheds a different light on it. The question is whether rent-seeking is more problematic with a weak, passive state than with a strong one. It could be that rent-seeking is even more common when the public sector only attempts to facilitate rather than create additionality through mission oriented policies that crowd in the private sector, making private investments happen that would not have anyway, a problem discussed in the economic development literature (Khan and Kwame, 2000). Or whether it is more problematic when theory tells a wrong story about who the innovators are (e.g. the ‘entrepreneurs’ or the venture capitalists), excludes the risk taking role of the public sector. Thus if the State is described as simply fixing markets, not actively shaping and creating them, it may over time also become less confident, and more easily corruptible by different actors who call themselves the ‘wealth creators’. It is these actors who can then convince policymakers to hand out favours in order to increase their ‘private’ wealth. In the US, capital gains tax fell by 50 percent in five years at the end of the 1970s as a result of pressure from the National Venture Capital Association (Lazonick and Mazzucato, 2012). More recently instead, big tech corporations have been lobbying the US government substantially more than Wall Street’s biggest financial companies (Bloomberg, 2016c). In fact, some rent-seeking may be encouraged precisely by the problematic assumptions regarding the role and value of public investment.

The article has emphasised the need of innovation for patient strategic capital that is not found in the private sector, both due to the short-termism of the private financial system, but also due to the properties of innovation: highly uncertain, cumulative, collective and with very long lead times. This leads to a depth and breadth of public investment that is broader than traditional perspectives admit. In particular we emphasised how the impact of mission oriented public investment along the entire innovation chain, and across the phases of the business cycle, is something that the green tech industry can learn from the experiences in sectors like biotech and ICT. The theoretical contribution of such evidence is that economic policy should be more about market shaping and creating than just market or system ‘fixing’.

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Is Technological Progress Obsolete?

By Joel Mokyr [94]

Abstract

In recent years, economists have revived the specter of slow growth and secular stagnation. From the point of view of economic history, what should we make of such doom and gloom prophecies? It is widely agreed that technological progress remains the main engine of economic growth. A major factor that stimulated and encouraged economic growth in the past was feedback from technology to science. Artisans and inventors in the past provided scientists with new and more powerful tools that led to scientific breakthroughs, which in turn eventually led to technological advances. In that way, technology pulled itself up by the bootstraps. In the past half century, the tools at the disposal of science have become hugely more powerful, and hence there is no technological reason for growth in economic welfare to slow down, although measurement issues may not always show a corresponding increase in productivity.

1 Technology Slow-down?

Techno-pessimism comes in two flavors. One is Gordon's (2016) technological slow-down hypothesis, that maintains that most of what could be invented has been, and that future innovation will have a much more limited effect on humankind (and will be too weak to forestall the other headwinds he foresees). The other is the apocalyptic hypothesis that foresees a world in which people, in some way or another, have been replaced and displaced by machines, mostly some combination of robots, artificial intelligence, and more sinister ways in which intelligent non-humans of our own creation will create some hazy form of dystopia.[95] A closely-related dystopian view is that technology will in some way or another become more powerful than people and that there is an inherent contradiction between ever advancing science and free will and that humans will become powerless against machines more intelligent than themselves (Harari, 2017, p. 284). The good news is that those pessimistic predictions cannot *both* be right. The even better news is that they can

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94 Departments of Economics and History, Northwestern University and Berglas School of Economics, Tel Aviv University. Some of what follows is based on Joel Mokyr, "The Past and the Future of Innovation: some lessons from Economic History," unpublished manuscript, 2017.

95 The dystopian view of a world in which nobody works was already foreseen by David Ricardo in an 1821 letter to J.R. McCulloch when he wrote that "if machinery could do all the work that labour now does, there would be no demand for labour and nobody would be entitled to consume anything who was not a capitalist and who could not hire or buy a machine" (Ricardo [1821] 1952, pp. 399-400). In such a dystopian world life is vapid and devoid of meaning, as originally imagined in Vonnegut (1974) and described by Rifkin (1995). Among twentieth-century economists, the best-known of the dystopians is Leontief (1983). Most apocalyptic and one-sided is Harari (2017, p. 330) who predicts "the creation of a massive new unworking class … a "useless class" [who] will not merely be unemployed — it will be unemployable." More sophisticated analysis equally concerned with labor-saving technological progress run amok can be found in Brynjolfsson and Macafee, 2014.

both be wrong. Leaving aside the more speculative predictions of various machines-eat-men dystopias, I will discuss briefly the concern that future technological progress will be slower and less significant than in the past.

The argument that the low-hanging fruits that affect economic welfare have all been picked at first glance carries some conviction. Gordon (2016, pp. 638, 641-42) writes that "the century 1870-1970 was unique. Many of these inventions could happen only once and others reached natural limits ... the innovation slowdown and four headwinds — inequality, education, demography, and debt — [imply] a bleak future in which median real disposable income will barely grow at all." Many of the twentieth century inventions he describes have indeed revolutionized daily life and created enormous consumer surpluses: he points to air conditioning, antibiotics, high definition music and television, running hot and cold water, household appliances, and communication devices that have made material life longer, more comfortable and reduced frictions. Have we reached some kind of saturation in that any new innovations will add smaller and smaller gains on the margin?

It is not clear whether the past decade has seen a slow-down of innovation. Economists have different measures of innovation, and all of them are flawed. The hazards of using TFP calculations as a gauge for innovation are well-known to any student of economic growth, as are the risks of relying on patent counts.[96] TFP can grow (or not) regardless of technological progress, and considerable technological progress can take place that does not get recorded as TFP growth.[97] Gordon's figures imply a growth rate of 0.4 percent annually for 2004-2014, which he contrasts with the 1.03 percent growth in the 1994-2004. Rather than come up with well-selected examples in which relatively few breakthroughs have happened in recent years (the kitchen and laundry room) as against areas in which in the past decade major breakthroughs have taken place (solar panels, LED lighting, and the miniaturization of computing), I will propose a somewhat different approach to technological progress in the future, based on historical experience.

2 Does Technological Progress have a Future?

Why, then, is it reasonable to expect technological progress to continue at a fast pace? It is perhaps fair to extend the arboreal metaphor by noting that science allows us to build taller and taller ladders to reach higher-hanging fruits. Based on rapidly improving scientific insights, technological breakthroughs have the potential to change life in the foreseeable future as much as they did in the century and a half

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96 For the record, the number of patents granted in the US between 1997 and 2015 increased by an average annual rate of over 5 percent, more than five times the rate of TFP growth in that period, and shows no sign of slowing down.

97 There has been a rapidly-growing literature that points to reduced competition and a loss of dynamism that can explain the slow-down of TFP growth in the U.S. in recent years (e.g., Decker et al., 2014). An influential paper by Hsieh and Klenow (2009) has shown the sheer magnitude that resource allocation can have on TFP. Most recent research has confirmed that fundamentals in the U.S. have changed since 2000 with lower competition and reduced anti-trust enforcement (Döttling, Gutiérres and Philippon, 2017). While some of that work deals with investment rather than TFP, it is plausible that they are subject to similar forces.

since the Civil War. Without making specific predictions on what areas of human life are most likely to be changed dramatically, at least some of the leading candidates are known: driverless cars, decarbonization of all energy consumption, additive manufacturing a.k.a. three-dimensional printing, new artificial materials, virtual reality and transcranial stimulators, artificial intelligence (enhanced by deep learning), robotics, and medical advances on a list of degenerative and neurological conditions that may significantly slow down the ageing process and increase QALY's if not extend life expectancy itself.[98]

As is often remarked, if the twentieth century was the century of physics, the twenty-first century will be the century of biology. Recent developments in molecular biology imply truly revolutionary changes in humans' ability to manipulate other living beings. Of those, two stand out: one is the ability to not only sequence genes at low cost but actually *edit* genetic sequences thanks to CASBS techniques.[99] The other is synthetic biology, which allows for the manufacturing of organic products without the intermediation of living organisms. The idea of cell-free production of proteins has been around for about a decade (Zhang, 2009), but only recently has its full potential become known to the public (*The Economist*, 2017a).

None of those predictions can be made with any certainty, and it is inevitable that some advances will be made that no one is forecasting, while other promising advances will disappoint. But the case that technological progress will accelerate does not depend on one area of technology or another. It is based on the observation that technology pulls itself up by the bootstraps by giving scientific researchers vastly more powerful tools to work with.

3 Artificial Revelation and Economic Growth

One way technology affected science was through more powerful instrumentation.[100] Humans have limited ability to make very accurate measurements, to observe extremely small items to overcome optical and other sensory illusions, and have limited computational ability. Technology consists in part in helping us overcome the limitations that evolution has placed on us and learn of natural phenomena we were not meant to see or hear — what Derek Price (1984) has called "artificial

[98] A novel area that has received notice recently is the development of "nanorobotics," the injection of extremely tiny devices into live bodies. Dubbed "nanomedicine," it is the process of diagnosing, treating, and preventing disease and traumatic injury, of relieving pain, and of preserving and improving human health, using molecular tools and molecular knowledge of the human body (Thangavel et al., 2014).

[99] Dyson (2015, pp. 2-3) suggests a future in which the tools of genetic engineering become available to individual breeders: "there will be do-it-yourself kits for gardeners … also kits for lovers of pigeons and parrots … breeders of dogs and cats will have their kits too … domesticated biotechnology … will give us an explosion of diversity of new living creatures … new lineages will proliferate to replace those that monoculture farming and deforestation have destroyed." His balanced view differs dramatically from the many alarmist accounts of gene editing that worry about imaginary "catastrophic" effects of these techniques (e.g., Cobb, 2017).

[100] There were other channels through which technology affected scientific research, such as setting the scientific agenda by showing that certain techniques could work even when it was not understood how and why they did.

revelation."[101] Much of the seventeenth-century scientific revolution was made possible by better instruments and tools, above all the trio of the telescope, the microscope, and the barometer. In the eighteenth century new equipment, such as Laplace's calorimeter and Volta's eudiometer, enabled the advances that created modern post-Lavoisier chemistry. A combination of improved microscopy and better lab techniques in the nineteenth century made the discovery of the germ theory possible, arguably one of the greatest advances in medicine of all time (Bracegirdle, 1993, pp. 112-114). In the twentieth century, the number of examples that demonstrate the impact of better instruments and scientific techniques multiplies. One of the greatest heroes of modern science is x-ray crystallography, first proposed by the German theoretical physicist Max von Laue (1879-1960) and realized by William Henry Bragg (1862-1942). The technique has been instrumental in discovering the structure and function of many biological molecules, including vitamins, drugs, and proteins. Its most famous application was no doubt Rosalind Franklin's work in 1953, which led to the discovery of the structure of the DNA molecule, but its use has been instrumental in twenty-nine other Nobel-Prize winning projects (International Union of Crystallography, 2017).

Some of the tools that serve scientific research today have been known in more primitive form for centuries; others are radical innovations that have no clear-cut precursors. Of the existing tools, the microscope is the most prominent one, as it is of course basic to science's tendency toward miniaturization: to operate at smaller and smaller (nanoscopic) levels. The Betzig-Hell super-resolved fluorescent microscope (whose developers were awarded the Nobel Prize for chemistry) is to Leeuwenhoek's microscope as a thermonuclear device is to a fourteenth-century fire bomb. The same can be said for telescopy, where the revolutionary Hubble telescope is soon to be replaced by the James Webb space telescope.

Other tools, however, are entirely new. The two most prominent are lasers and high-powered computers. Laser technology is a truly game-changing scientific tool; when the first laser was developed, it was said, its inventors thought it was a technique "in search of an application." But in the 1980s, lasers were already used for cooling micro samples to extraordinarily low temperatures, leading to significant advances in physics. Nowadays, its uses in science have a dazzling range. Among its many applications, one of the most important is LIBS (Laser Induced Breakdown Spectroscopy), which is an astonishingly versatile tool. It is used in a wide range of fields that require a quick chemical analysis at the atomic level, without sample preparation.[102] LIDAR (light radar) is a laser-based surveying technique which creates highly detailed three-dimensional images used in geology, seismology, remote sensing, and atmospheric physics. But lasers are also a mechanical tool that can ablate (remove) materials for analysis. For laser ablation, any type of solid sample can be ablated for analysis; there are no sample-size requirements and no

[101] The connection from technology to science was formulated in an especially compelling fashion by the late Nathan Rosenberg (1982).

[102] LIBS is applied in remote material assessment in nuclear power stations; geological analysis in space exploration; diagnostics of archaeological objects; metal diffusion in solar cells; in biomedical applications to analyze biological samples like bones, tissues and fluids, and to detect excess or deficiency of minerals and toxic elements in bodies.

sample preparation procedures. Chemical analysis using laser ablation requires a smaller amount of sample material and a focused laser beam permits spatial characterization of heterogeneity in solid samples. Among its many other uses, laser interferometers have been used to detect the gravitational waves Einstein postulated, one of the holiest grails in modern physics.

Computers are omnipresent in the modern world, but economists must reckon their long-run effect on productivity to be far larger than their immediate effect because they have revolutionized scientific research, which has undergone a veritable phase transition. A new era of data-science has arrived, in which models are replaced by powerful mega-data-crunching machines that detect patterns that human minds could not have dreamed up and cannot fathom. Such deep learning models engage in data-mining using artificial neural networks. Rather than dealing with models, regularities and correlations are detected by powerful computers even if they are "so twisty that the human brain can neither recall nor predict them" (Weinberger, 2017, p. 12). Here the slogan might well be: who needs causation as long as we have correlation? In some sense, there is nothing new here: there was always an inductive method in science, in which scientists collected data on plants, shells, and rocks and looked for regularities without a full understanding of the underlying laws. The difference is perhaps just in scale, but in these matters scale is everything. Much as the James Webb is to Galileo's first telescope, the huge data banks of mega crunchers are to Carl Linnaeus's notebooks.

But computers can do more than crunch data: they also simulate, and by so doing, they can solve fiendishly complex equations that allow scientists to study hitherto poorly-understood physiological and physical processes, design new materials *in silico*, and simulate mathematical models of natural processes that so far have defied attempts at closed form solution. Such simulations have spawned entirely new "computational" fields of research, in which simulation and large data processing are strongly complementary in areas of high complexity. Historically some scientists dreamed about such a tool, but it is only in the most recent decades that scientists will have the capability to do this at a level that could eventually affect our technological capabilities. With the advent of quantum computing, computational power in many of these areas will increase by a substantial factor.[103]

4 Growth and Productivity

While continued growth in technology will continue apace, there are a number of reasons why technological progress and various productivity measures will not necessarily move in lockstep. For one thing, digitalization implies very low or zero marginal costs for many of the most widely used new products and services, and in a competitive economy, many products and services are sold at prices that are close

[103] The idea of quantum computing was proposed by Richard Feynman more than thirty years ago, but algorithms for it turned out to be very difficult to write and for decades it remained, much like nuclear fusion, a technique that was always "a few decades away." Recent advances, mostly in software writing, have raised hopes for a myriad of applications (e.g. Gibney, 2014).

to or equal zero with revenues coming from “bundling”, such as targeted advertising. Services that imply large gains in consumer services, such as encyclopedias, search engines, social media, and GPS, are essentially handed out free and hence do not enter national income accounts. To be sure, innovations that imply huge gains in consumer surplus have occurred in the past, but their rate of progress has accelerated with modern production technology.

Moreover, much technological progress in recent years has affected leisure activities and not production per se. An example is the vast expansion of activities that can be done online, which saves on the kind of transactions cost that national income accounting has always counted, misleadingly, as leisure: shopping, dealing with government offices, and many medical services are obvious examples.[104] Telecommuting, while perhaps growing slower than was anticipated, is saving on transportation costs and time. None of those improvements is accounted for in the National Income accounts and hence does not show up in TFP calculations.

Finally, it could be argued that past productivity growth calculations have been overstated because they have failed to account for the unanticipated negative externalities of technological progress sometimes known as bite-back effects (Tenner, 1997). Specifically, past industrial production and transportation have used up scarce resources without paying for them, above all the use of the earth’s atmosphere and oceans. Had those inputs been fully accounted for, they would have reduced productivity growth by unknown amounts (since there is no obvious way to place a price on such costs as climate change and ocean acidification). It seems likely that much of future growth will have to be earmarked to pay for the unpaid costs of past technological progress, meaning that a portion of past productivity growth must be spread over a longer period, biasing any observed declines in TFP.

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[104] Internet sales have reached 8.5 percent of total sales in 2015 (Bureau of the Census, 2017). Slightly more than half of all Americans now prefer to shop online, but this rises to 67 percent for Millennials. A full 40 percent of online shoppers say they couldn’t live without online shopping (Big Commerce, 2017).

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Technology, Innovation and Industrial Organization

By Hal Varian[105]

Abstract

Information technology will continue to have a large impact on economic activity. IT has allowed startups to dramatically reduce their fixed costs by outsourcing many business processes. Nowadays, huge amounts of data are generated as a byproduct of production. The challenge in utilizing this data lies mainly in acquiring the necessary talent. The increasing importance of intangibles like design and software has posed challenges for economic measurement. Finally, demographic forces will lead to labor force growth that is substantially less than population growth in many developed economies, so increasing productivity growth is essential.

The chairman suggested that I address three questions.

1.1 Will the innovations of tomorrow be driven by new firms or established incumbents?

Both. Competition among the large IT firms is intense. They compete in operating systems, office productivity applications, cloud computing, devices, advertising services, and many sectors. These services are widely used by both consumers and businesses around the world.

It is because of this competition that prices are low — often free — and innovation is rapid.

These services are also widely used by startups. Small businesses can buy cloud computing and networking from Amazon, Google, Microsoft or others. They can use open source software tools like Python, Hadoop, TensorFlow, and the like. This fact that companies can buy such services “on demand” has dramatically reduced fixed costs and led to significant entry by new enterprises. Between 2010-2017 5,110 venture-funded companies have been founded in Europe with $42.9B raised during this period [Source: Sandhill Econometrics].

It used to be an entrant had to build their own computing environment which was a significant fixed expenditure and made entry costly.

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Nowadays small firms can rent computing, networking, and tools in the cloud. Providing web services is now a constant returns industry: what was previously a fixed cost is now a variable cost. I refer to this phenomenon as the "return to constant returns."

It is easy to get started and it is easy to grow — if you have a good product. Consider Netflix for example: it has no servers of its own. It runs its entire operation through Amazon Web Services. Similarly, Spotify, Evernote, Coca Cola, Airbnb, Costco, and Snapchat all run on Google's cloud.

This scalability is not just on the technology side, but also on the business process side. Companies can find and hire employees through LinkedIn, find customers using Salesforce, do their accounting using QuickBooks, outsource user support using ZenDesk and so on. There are hundreds of specialized support services that can be purchased at whatever scale is desired. Adam Smith once said "the division of labor is limited by the extent of the market." Nowadays we can say "the division of business services is limited by the extent of the market." But with the internet even a small firm can serve a global market, so we get very fine degree of specialized services readily available.

1.2 Why are the latest technologies not being adopted by a sufficiently large share of firms and what can be done about it?

The hot technology of the day is machine learning. There is now a computer in the middle of most economic transactions, so the data from those transactions can be captured and stored. Due to this, everybody now has a data warehouse in some form or other. The software for data management and analysis are mostly free. Python, Hadoop, MySQL, TensorFlow and similar systems are open source. Cloud computing provides the platform for analysis; the burden of system administration is no longer relevant. Expertise is now the scarce factor, but not for long. Universities are rushing to offer data science degrees and every year more and more qualified candidates become available. The main difficulty is finding experienced data analysts who can assemble and manage a team. The first hires are the most critical since they will build the rest of the group. The job applicants all want to work where they will learn the most — they want to join the biggest team and best team. However, this is a transitory problem — the market is sorting it all out. Enterprises are assembling teams of data scientists to take advantage of the widely available computational resources.

1.3 What are the most important factors that can ensure cross-fertilisation between fundamental university research, industry research and development and business investment?

Let me talk specifically about Google. We provide TensorFlow as an open source package for machine learning, particularly focused on "deep learning." This software makes it easy to run machine learning on multiple computers in parallel. It also transparently supports of special purpose hardware such as GPUs and TPUs (graphical processing units and tensor processing units). Google also provides training data for machine learning search. For example, we have donated 9 million images, each with 6,000 labels to the Open Image project. We also provided 8 million YouTube videos (representing over 500,000 hours of video), along with labels from a diverse set of 4800 Knowledge Graph entities. We've also donated 1,000 Cloud TPUs to universities. Each TPU offers 180 teraflops of floating-point performance and 64GB of memory.

We've donated the software, the hardware, and the data to universities. Why? Because then when we hire their students, they hit the ground running — they are productive from the first day on the job. They're already used to the hardware and software that they've seen in their classes and labs. Other tech companies such as Microsoft and Facebook are doing the same thing. The major form of competition these days is competition for expertise.

1.4 What about the impact of robotics on jobs?

Automation has been going on for decades, or even centuries. Yet over this time society has become richer, employment has increased, and the standard of living has improved. Yes, there will be disruptions in the future, but these can be handled.

One important factor that is not sufficiently appreciated is the accelerating fall in the supply of labor. In the US the labor force is currently growing at half the rate of the population. The decade of the 2020s will see the lowest growth rate of the labor force since the Great Depression. In the 1960s and 1970s we saw two big shocks to the labor supply from baby boomers and increased participation by women. The baby boomers are now retiring and female participation has plateaued. Without immigration, the labor force in the US would actually decline.

The US has good demographics compared to other industrialized countries such as Japan, China, Korea, Germany, and Italy. It is not a coincidence that these countries are also investing heavily in automation. Without an increase in worker productivity that makes up for the reduction in the labor force we could easily see these economies contracting.

1.5 What about the productivity slowdown?

First, improving productivity growth is critical due to the demographic forces I just described.

Second, the Twentieth Century is a hard act to follow. As Bob Gordon has amply documented, the technological change from 1870 to 1970 was truly phenomenal. My own grandfather once told me that he was born when people got around by horse and buggy (1900) and lived to watch men walk on the moon only 69 years later!

Third, though I agree that the productivity growth is real, it is also true that there are considerable measurement problems with GDP particularly in areas involving rapid quality change.

Take for example, photography. In 2000 there were 8 billion photos taken in the world and each cost about 50 cents for film and developing. In 2015 there were about 1.6 trillion photos taken, each costing for almost zero. Even today, cameras, film, and developing services are part of the Bureau of Labor Statistics photography price index — but hardly anyone buys these products any more!

The same story applies to GPS systems. These systems became commercially available in the late 1990s. They cost over $1000 a unit and were deployed primarily in the trucking industry. GPS devices contributed to productivity growth in this industry, with trucking productivity growing about twice as fast as overall productivity. The price of GPS units became cheaper and cheaper, and more and consumers purchased them. As the price fell, real GDP rose … right up to the point where the price hit zero! GPS systems became part of smartphones, and turn-by-turn directions became available to everyone for zero incremental cost. At that point, measured improvement in embedded GPS systems stopped.

Overall smartphones may have decreased measured GPD. A smartphone replaces a landline, a camera, a GPS, a land line, a game machine, an ebook reader, a computer, a movie player, an audio player, a map, a password generator, a fitness monitor, an alarm clock, a web browser, a calculator, a recording device, video camera, and more. The sales of all these devices fell, and there is no quality adjustment for smartphones! So overall, measured GDP could have been negatively impacted by these devices.

Nowadays, all smartphone are assembled outside the US. They are counted as imports when they arrive in a port, even though the major contribution to their value is the software and design that is in fact created in the US by Apple and Google. A Qualcomm chip that is designed and manufactured in the US and shipped to China as a smartphone component is counted as a US export, but the operating system of that mobile phone is not counted as an export. This is not a disparagement of the statistical agencies — it is fundamentally more difficult to count a file transfer than a physical device passing through a US port.

The result is that intangibles like design and software get undercounted in GDP. This isn't just a high tech problem, but also an issue with clothes, shoes, electronics, furniture, auto parts, and so on. Many products are designed in the US and manufactured elsewhere and the design component of the value is difficult for statistical agencies to value. One consequence is that quality improvements in imports don't show up in GDP, even when those quality improvements may come from improved design and software that originate domestically.

An innovation deficit behind Europe’s overall productivity slowdown?

By Reinhilde Veugelers[106]

Abstract

Europe maintains lofty ambitions for building its future prosperity and safeguarding its social model through innovation. An ambitious target of devoting 3% of GDP to R&D was already set in 2002. The same 3% was again targeted in the EU2020 strategy. Despite attention to innovation as a driver of growth and despite R&D targeting, Europe’s performance on innovation remains weak to date. At the same time, Europe’s TFP growth continues to display a lacklustre performance. Rather than looking at productivity growth through the residual TFP construction, this contribution looks directly into the evidence on innovation as a potential source of productivity growth. We look at the evidence on an innovation deficit behind Europe’s overall productivity slowdown in Sections 1 and 2. Sections 3 and 4 try to get at why it is so hard to improve Europe’s innovative performance and identify some policy implications.

1 The power of innovation as a growth machine

Before we look at the direct evidence on innovation in Europe, this section first looks at specifics of innovation investment.

1. Like capital investment, investments in innovation can create private welfare for the innovator, generating a private rate of return and motivating him to invest in the first place. But innovation’s full creative potential benefits not only directly the initial innovator. As new knowledge diffuses, it can be used by others who can apply the new knowledge into new, often unrelated, applications. This is the well-known public good character of ideas.

It is this diffusion power from innovation that makes innovation such a powerful growth machine. Estimates for social rates of return can easily become multiples of the private rate of return[107]. But this diffusion cannot be taken for granted. It requires codification and transferability of knowledge together with the capacity and incentives to adopt and adapt knowledge at the receiver side. The patent system has as its mission, not only to provide incentives to the original innovator, but also in return, to disclose the invention, such that it can be more easily used by others

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[107] For more on private and social rates of return, see eg Veugelers (2016).

(when the patent expires). But perhaps the most potent mechanism for the transfer of new know-how is when researchers who embody the new knowledge move from the innovating entity to other sectors or other firms.

Recent evidence from OECD (Andrews et al. (2017)) shows there may be a problem of diffusion/adoption, suggesting a problem in the diffusion section of the innovation-growth machine rather than innovation at the frontier, which is causing an increasingly larger divide between innovators at the frontier and laggards failing to use the opportunities from new, typically digital, technologies to catch up.

2. Innovation's full economic returns typically require a long time lag before full diffusion takes place. A longer term horizon is therefore needed to evaluate the full social returns to innovation, much longer than for other types of investments.

3. Innovation is a creative power, but it also destructs old technologies/products/skills. These are the two faces of the creative destruction power of innovation. Creative ideas, particularly those that are of the more radical, disruptive type, typically do not come from incumbent firms, who do not want to cannibalize their existing positions, but often come from new firms challenging incumbents, or when they come from incumbents, because they are challenged by new firms. If these radical innovations will come to be, they therefore require absence of entry barriers for new challengers and framework conditions for smooth transitions.

2 Assessing Europe's innovation-based growth deficit

As we care about innovation because of its power to generate growth, what we should measure are the effects of innovation on overall welfare. But unfortunately, we don't have good measures of the effects of innovation, particularly on the social value of innovative investments, which is what we ultimately care about[108].

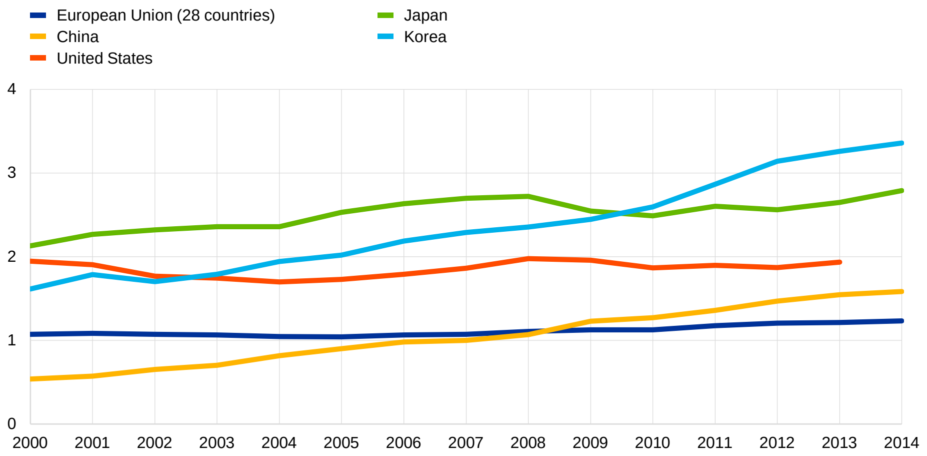
What is commonly measured are innovation inputs, with perhaps the most focal indicator the business sector expenditures on Research and Development (the so called BERD series, regularly published by the OECD/Eurostat). These expenditures reflect at the same time the capacity as well as the incentives of the private sector to use scientific and technological opportunities to launch innovations that will improve their profitability and competitiveness. Low scores on this indicator may identify deficits in innovative capabilities by the business sector, together with deficits in the framework conditions for innovation. It is therefore a major indicator for EU innovation policy to monitor. It is targeted as part of an overall 3% target for a country's R&D-to-GDP ratio to be around 2%. Chart 1 shows that the EU Business R&D share of GDP, although not declining over time, is not increasing fast enough to catch up. It continues to hover around 1%, which is consistently below other

108 See eg Veugelers (2016).

countries like the US, Japan and Korea and since 2008, also below the score for China.

Chart 1
Trends in Business R&D in the world

(BERD as a % of GDP)



Source: Own calculation on basis of EC, Innovation Union Scoreboard, 2016, based on OECD.

Broader than R&D are the expenditures for innovation, which also include expenses for introducing innovations not new to the market, but new to the firm, and therefore also measure diffusion through the adoption of innovations from others. The Eurostat-CIS data for Germany provide a panel comparable over time, allowing to assess both the trends in number of firms which are innovation active and the trend in expenditures by innovation active firms. These data show that the share of German firms that are innovation active has dropped over time (EFI 2015 and Rammer & Hünermund (2017)). Particularly, many small and medium-sized firms have discontinued their investments in innovation. This is consistent with the supra reported OECD evidence on the diffusion deficit (Andrews et al. (2017)). As a consequence, the inequality of innovation activities (as measured through the Gini-coefficient for innovation expenditures) has become larger over time in Germany. At the same time, they find a high stability in the group of firms with the largest R&D budgets in Germany. Overall, the total expenditures by the corporate sector on R&D are not decreasing in Germany, even slightly increasing, but the innovation landscape is becoming increasingly more unequal and concentrated in a few firms.

Ongoing work at Bruegel (Veugelers & Kalcik (2017)) tries to examine for Europe the trend in corporate R&D expenditures to become more concentrated in a few “superstars”. We use the information on European firms from the 2005 to 2015 editions of the EC-JRC Scoreboard of largest R&D spenders worldwide. The total investments of R&D by these firms remained stable during the crisis and continued to go up after the crisis (at least nominally). First preliminary results show that the distribution of R&D expenditures by European Scoreboard firms in the latest year available (2015) is highly unevenly distributed, much more than their sales and employment. Most of the inequality in R&D expenditures is due to the difference between the Top 10% and the rest. Inequality in the Bottom 90% only accounts for

7% of total inequality. The Top 10% of European Scoreboard firms represent 77% of all European Scoreboard R&D expenditures. The Top 1% of R&D spenders account for almost one third of all European R&D scoreboard expenditures.

When looking at the trend in inequality and concentration over time, from 2005 to 2015, the European Scoreboard data do not signal increasing inequality in R&D; on the contrary, the trend is downward and so is the trend in inequality in sales and employment of the European Scoreboard firms. This contrasts with the work of Autor et al. (2017) for the US corporate sector, who find an increasing trend of more concentration of sales and employment. It is in line with Philippon et al. (2017), who found that unlike for the US, concentration of sales has not increased, even decreased in Europe. Nevertheless, the downward trend in concentration of European R&D expenditures still leaves high levels of inequality. Furthermore, the decline in R&D concentration among European Scoreboard firms seems to have stopped since 2011. Since 2012, particularly the Top 1% R&D spenders have forged ahead. This more recent trend in increasing inequality of the R&D landscape and the increasing concentration in fewer firms, holds even more outspokenly for the US and in the digital sectors.

Should we worry about high and possibly increasing concentration of R&D expenditures? This depends on what is driving the high concentration. High concentration of corporate R&D in a few firms can arise from higher efficiency of larger firms. The speed, depth and breadth of technological change, large sunk investments for building R&D capacity, the need to access networks and alliance partners for innovation are all characteristics that would predict R&D races increasingly characterized as “winner take most”, where large firms are the most likely winners (Schumpeter Mark I) (Acemoglu & Hildenband (2017)). However, the speed with which the latest technological innovations get diffused or spill over voluntarily or involuntarily should lead to catching up and dissipating of previous leadership positions. If the diffusion process happens sufficiently fast, differences between leaders and laggards should shrink over time. A persistent concentration could thus suggest a diffusion deficit. At the same time, the fluidity of the R&D environment needs to be recognized where competences, network positions and technology leaderships of incumbents can be quickly overturned by radically new technology avenues. This will disrupt the incumbent leaders, creating room for new winners (Schumpeter Mark II). Even if the R&D landscape will still be concentrated, new tenants may inhabit the top.

An important issue for any potential policy concern on concentration of the R&D landscape is therefore to examine whether the “superstar R&D firms” are incumbent market leaders exploiting their market power or incumbent R&D superstars exploiting their superior innovative capacities and experience, or new superstar firms introducing radically new innovations. High or increasing concentration may be welfare enhancing if it follows from higher efficiency of leading firms, but it becomes a policy concern if it is a reflection of failing diffusion of innovations between leaders and laggards or from incumbents raising entry barriers for new potentially more efficient leaders. First results from the ongoing Bruegel work (Veugelers & Kalcik (2017)) shows a high incumbency among leading firms in Pharma/Biotech, consistent with high economies of scale, scope and experience in this sector. This sector does show a trend towards decreasing concentration, suggesting diffusion and entry of new firms among European Scoreboard firms, notably from biotech, be it that the decreasing trend is very modest.

In the digital sectors, the incumbency effect is smaller than in Pharma. While almost 90% of the R&D expenditures of the largest 20 R&D spenders in the Health sector came from firms that were already the largest 20 R&D spenders in 2005, this share is below two thirds for ICT sectors. Nevertheless, in view of the rapid changes in technology in this sector, one would have perhaps expected a smaller incumbency effect.

3 Uncovering Europe’s innovation deficit

The continued business R&D deficit, the lack of diffusion and the high, relatively, stable, concentration of R&D expenditures in a few leading firms, is central for understanding Europe’s continued deficit in innovation based growth. It is a symptom of its low capacity for structural change and shifting towards new growth areas. But what explains this business R&D deficit? And why is this deficit so persistent? In line with Aghion et al. (2007) and others, Europe’s persistent business innovation gap can be correlated with its industrial structure. New firms fail to play a significant role in the innovation dynamics of European industry, especially in the high-tech sectors. This is illustrated by their inability to enter, and more importantly, for the most efficient innovative entrants, to grow to world leadership. The churning that characterizes the creative destruction process in a knowledge based economy encounters significant obstacles in Europe, suggesting barriers to entry and growth for new innovating firms that ultimately weaken Europe’s growth potential. Bartelsman et al. (2004) found that post entry performance differs markedly between Europe and the US, which suggests the importance of barriers to company growth. This inability for new European firms to grow large seems to manifest itself particularly in the high-tech, high-growth sectors, most notably in the digital sectors. This correlates with a lower specialization of the European economy in R&D intensive, high growth sectors of the nineties, again most notably the digital sectors.

This structural European innovation deficit story, related to company age and sectoral make-up of its economy, has been investigated in more detail in a Bruegel Policy Brief and Contribution (Veugelers and Cincera (2010)), confirming that the major source of Europe’s lagging business innovation deficit relative to the US is the lack of young companies that have grown into world-leading innovators (“Yollies”) in new innovation based growth sectors, most notably in digital and health sectors.

Why are there fewer companies starting up and growing into world leading innovators in Europe? The most frequently cited explanation for the differences in dynamic structure between Europe and the US is a greater willingness on the part of US financial markets to fund the growth of new companies in new sectors. Although the evidence clearly supports the importance of access to finance for highly innovative growth projects, the evidence also shows nevertheless that one cannot ignore the importance of other impediments to innovation, reducing the expected rates of return on R&D investments. These other barriers include insufficient demand for innovations, regulatory burdens and access to skills (Schneider and Veugelers (2010)). Cincera and Veugelers (2014) examine econometrically the rates of return to R&D investments for world leading R&D investors. They find that, while in the US, young firms succeed in realizing significantly higher rates of return to R&D as compared to their older counterparts, European innovating firms fail to generate significant rates of return, even if they are young and even if they are in high-tech sectors.

All this is a strong reminder that the innovation deficit in Europe is systemic. Access to finance cannot be tackled in isolation, but should be embedded in an innovation environment that also addresses other barriers to innovation. As these other barriers reduce the expected rates of return on highly innovative projects, they affect the appetite of financers to provide funds for these projects.

4 Some policy suggestions for addressing Europe's innovation deficit

What types of policy interventions are needed in Europe to address these specific barriers? And how targeted do they need to be? A first important remark is that a general innovation policy aimed at improving the environment for innovation remains necessary. This overall innovation policy is also needed to power the diffusion engine. Such an overall innovation policy should further the integration of European capital, labour, product and services markets, make it easier for players in the innovation system to interact and, at the same time, ensure healthy competition and an innovation friendly regulatory framework.

Such an overall innovation policy will be necessary, but it will not be sufficient. Policy measures are also needed to tackle the specific barriers faced in new sectors by new companies. This includes inter alia access to external finance for fast growing highly innovative projects, by public funding and/or by leveraging private risk funding.

As there are still too many unknowns about whether and which interventions are effective for which countries, policymakers are advised to engage in close monitoring of emerging innovative markets. Monitoring should include a strong prospective angle, able to identify new emerging markets well in advance so that a pro-active policy mix can be identified for the very earliest phases of development, when the risk of market failure is at its highest.

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INVESTMENT AND GROWTH
IN ADVANCED ECONOMIES
ECB FORUM
ON CENTRAL
BANKING

Sources and Mechanisms of Stagnation and Impaired Growth in Advanced Economies

By Robert E. Hall[109]

Abstract

Advanced economies generally grew in real terms from 2000 until they stumbled badly after the financial crisis in late 2008. Their performance subsequent to the crisis has varied widely. This paper takes a close look at overall performance from 2000 onward of six advanced economies: France, Germany, Italy, Spain, the United Kingdom, and the United States. The paper's basic measure of performance is the level of real labour earnings per member of the population. This measure is appropriate because a main focus of concern about economic stagnation has been on low growth or even shrinkage in family incomes. Post-crisis performance was remarkably heterogeneous across the six countries. Although performance was general sub-par, no single theory of stagnation fits the data.

1 Introduction

A central concern today is that the financial crisis of late 2008 sent many advanced economies into some form of stagnation. This paper takes real labour earnings per member of the population as a suitable measure of performance in judging stagnation. Labour earnings measure the well-being of the majority of the population. The primary alternative to this measure would be real output per person, the volume of resources available for all purposes. As the paper shows, downward shifts in the share of output accruing as income of workers are an important source of stagnation in several of the countries studied here.

Figure 1 shows the evolution of indexes of earnings using annual data stated in logs, over a period of seven years before the crisis and seven years following. The slope of each country's line shows its rate of growth. All six economies experienced some immediate decline immediately following the crisis. Germany and France had minor pauses in growth of earnings. The other four countries — Italy, Spain, the United Kingdom, and the United States — suffered large immediate declines in earnings. Among these, the UK and the US had weak recoveries with low but positive growth of earnings. Spain and Italy experienced declining earnings through the end of the data in 2014. Of the six countries, two — France and Germany — showed no

[109] Stanford University.

obvious signs of stagnation, one — the US — suffered a substantial decline, followed by partial recovery, two — Spain and Italy — plunged almost continuously since the crisis, and the last — the UK — grew very rapidly from 2000 to the crisis and has been level since then.

Concerns about stagnation have been widespread as the disappointments about growth unfolded. At first, it appeared that the crisis had triggered unusually large cyclical contractions. Stagnation theories focused on deficient demand. The monetary policies of the three central banks responsible for the six countries were constrained by the effective lower bound on interest rates. But, as some of the economies — notably the UK and the US — returned to full employment, it became clear that other theories of stagnation were needed to explain poor growth.

This paper attacks the diagnosis of stagnation by breaking down the movements of real earnings per member of the population into seven components. Two of the components are related to traditional thinking about cyclical fluctuations: the employment rate (one minus the unemployment rate) and weekly hours, though a lingering low employment rate is a type of stagnation in some economies, notably Spain, and persistent declines in weekly hours have occurred in other economies. Multifactor productivity, the best available measure of technological advance, is a component with large contributions in five of the six economies. The capital/output ratio is the natural measure of capital intensity in the paper's framework; it is a component that helps understand the role of capital formation. Labour-force participation is a component with important movements in Spain and the US. And declines in the labour share of national income have an important role in declines in earnings in five of the six economies.

2 Real earnings per member of the population

This section presents the chain of relationships running from a set of variables, including multifactor productivity, the capital stock, and the population—to real earnings per person. The relationships are definitional. They reflect the way government agencies compile the data. I arrange the definitions in a way that is intended to be informative about the determinants of the variations in growth of real earnings. But it is important to keep in mind that the relationships are not causal. For example, it would be an overstatement to say that some of a decline in real earnings was caused by a decline in the income share of labour. Rather, what one can say is that forces that caused declines in the labour share also caused real earnings to grow more slowly than real income.

The first relationship is

Total real earnings = [labour share] × [real output]

The labour share is one of the components of the ultimate decomposition. I further break down

Real output = [output per unit of labour input] × [volume of labour input]

Output per unit of labour input = function of [multifactor productivity] and [capital/output ratio]

Volume of labour input = [hours per worker] × [workers per member of the labour force] × [members of the labour force per person of working age] × [people of working age as a fraction of the total population]

The result is a seven-way breakdown of real earnings per member of the population among the following:

4. Labour share;
5. Multifactor productivity;
6. Capital/output ratio;
7. Hours per worker;
8. Employment rate: 1– unemployment rate;
9. Ratio of labour force to working-age population;
10. Ratio of working-age population to the population of all ages.

I emphasize that the measure considered here is real earnings per member of the population, not per worker. This measure encompasses changes in the labour force and unemployment, as well as in the earnings of workers. The measure focuses on total resources created by workers per member of the population, before deduction of taxes, exclusive of additions from government transfers (public benefits), and inclusive of fringe benefits provided by employers. It includes contributions for public retirement and health programs.

The Appendix explains the function relating output per unit of labour input to multi-factor productivity and to the capital/output ratio.

Traditional macro theory separates the movements of output and employment into cyclical and trend components. Cyclical movements are transitory and the trend component moves smoothly and persistently over time. This view is encountering more and more scepticism as it has become clear that, at a minimum, there is a substantial residual component that is neither cyclical nor slow-moving.[110] In some countries, notably the US, the unemployment rate appears to be a reasonable indicator of a cyclical component, but in others, such as Italy and Spain, unemployment is not a mean-reverting variable and the identification of cyclical and non-cyclical components does not appear to be feasible. For that reason, this paper does not attempt such a decomposition. Its decomposition does assign roles to variables that differ in their traditional assignment as cyclical and non-cyclical — for example, the employment rate is a cyclical variable at least in the US — but the

[110] See Fernald, John, Hall, Robert, Stock, James, and Watson, Mark (2017), "The Disappointing Recovery of U.S. Output since 2009," *Brookings Papers on Economic Activity*, (1), forthcoming, for an extended discussion of this point in the US context.

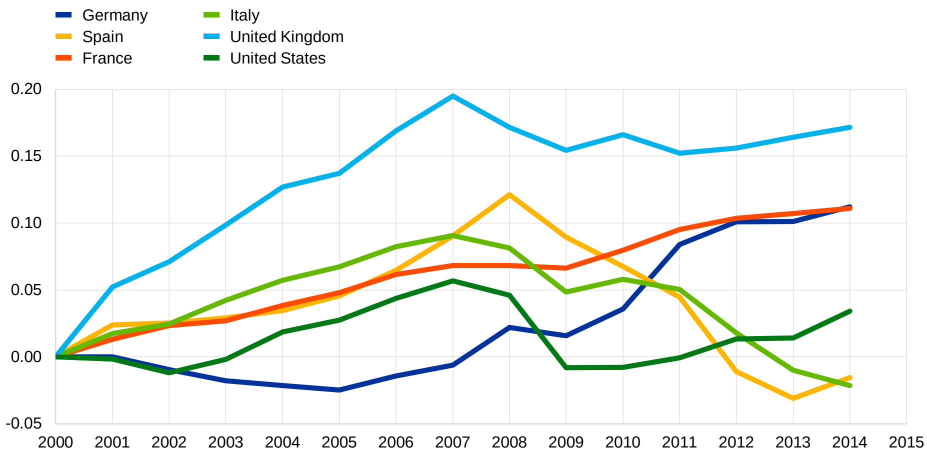
basis for the decomposition is not a hypothesis of cyclicality, but rather is derived from ideas in growth theory.

3 Data

The data come from the website OECD.Stat.

Figure 1
Real Compensation per Member of the Population

(log points of increase since 2000)



4 Results

The following series of tables and figures, all in the same format, show the movements of real compensation and its seven components. Each reports the log of an index, where the index itself starts at one, so the log starts at zero. The vertical axis is in log units, so the slopes are rates of growth. Each unit of increase of 0.1 is growth of a bit over 10 percent (100 × (exp(0.1)-1) to be exact). In the figures, the vertical axis runs from –0.2 percent per year to +0.2 percent. Thus all the figures are comparable to one another. The log index for earnings over population is exactly the sum of the log indexes of the components, by construction.

Table 1 compares the annual percentage growth of real compensation per member of the population, in the crisis and later, to its growth in the calm years from 2000 through 2007. Growth rates were heterogeneous in the earlier period, ranging from just below zero to over three percent per year. Germany's negative rate could be called stagnationary. After the crisis, four countries had negative growth over the seven-year span. Two of those, Italy and Spain, were deeply negative, but the other two, the UK and the US, were also somewhat negative. France, though positive, was low enough to be called stagnated. Only Germany grew at a non-stagnation rate.

Table 1

Average Annual Percentage Growth Rates of Real Compensation per Member of the Population in the Pre- and Post-Crisis Years

(average annual percentage growth rates, in percentage points (see title))

Country	2000-2007	2007-2014
Germany	-0.10	1.97
Spain	1.51	-1.77
France	1.14	0.71
Italy	1.51	-1.87
UK	3.25	-0.39
US	0.94	-0.38

Recall that Figure 1 shows the annual evolution of real compensation by country.

The behaviour of earnings per member of the population in the period after 2007 could hardly be more different. Only Germany grew faster after the crisis than before. France enjoyed positive growth after 2007, but at a substandard rate. Italy and Spain had alarming shrinkage of earnings and the UK and the US dropped to slightly negative growth rates, in contrast to positive growth in the earlier period. The drop in the case of the UK was about 3.6 percentage points of growth.

4.1 Labour's share of total income

Table 2 compares the annual growth rates of the log of the labour share in the two periods for the six countries. These and other calculations showing the components are in units that add up to the totals in Table 1. For example, the figure 0.25 for France's labour share in the earlier period means that the share rose, on average, by a multiple of exp(0.0025) = 1.0025 in a year, so a share that was 70 percent in one year would grow to 70 × 1.0025 = 70.18 percent in the next year. The labour share was on a slightly upward trajectory in the earlier period — only Spain experienced a decline.

Table 2

Average Annual Growth of the Log of the Labour Share in the Pre- and Post-Crisis Years

(log points of the share)

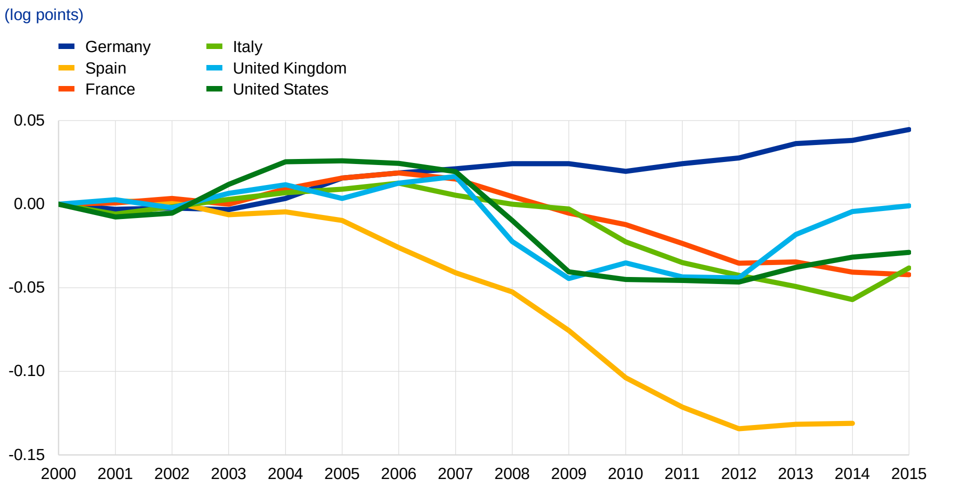
Country	2000-2007	2007-2014
Germany	0.35	0.28
Spain	-0.68	-1.50
France	0.25	-0.93
Italy	0.09	-1.04
UK	0.28	-0.35
US	0.32	-0.85

On the other hand, every country except Germany had a decline in the labour share after the crisis. For Italy and Spain, the share decline accounted for more than a percent per year of the decline in real earnings per person, and in France and the US, the decline was just under a percent per year. The declining labour share was an important contributor to the overall stagnation in labour earnings after the crisis. This aspect of the post-crisis stagnation has received relatively little attention.

Figure 2 shows the annual evolution of the log of the labour share.

Figure 2

Annual Growth of the Log of the Labour Share



The role of the declining share of output, and thus of real income, in the overall decline in earnings growth is striking. The value of the income generated from the production of output has three major components — labour earnings (well over half), the return to plant and equipment (an important part of the remainder), and the return to intangibles (the rest). Research is approaching a consensus that the share of the return to plant and equipment has probably not grown enough to explain the decline in the labour share. Rather, growth in the intangible share accounts for the shift away from labour.

The intangible share has two distinct elements. One is intellectual property. Firms invest in technologies and earn returns reflecting the advantages over rivals that the technologies deliver. The value of newly created intellectual property is included in the national income and product accounts in the form of reported flows of investment, which the accounts cumulate to estimate the intellectual property component of the capital stock. The second element of the intangible share is the return to market power that cannot be attributed to new technology. Large businesses are growing relative to their smaller rivals, so product markets are becoming more concentrated. Oligopoly theory generally associates concentration with higher margins of price over marginal cost. Some economists believe that more vigorous policies to prevent concentration of markets might have avoided part of this shift.

Tech companies like Apple and Google sell their products for prices far above marginal cost, so their growth since 2000 would be a contributor to the rise in the overall markup ratio. Pharmaceuticals have also contributed to markup growth. The growing tendency for advanced-country firms to outsource production to other countries but to retain research, development, branding, and other costs domestically that are not part of marginal cost has further contributed to the change. The hypothesis of markup growth is fairly new to macroeconomics and it remains to undergo serious quantitative verification, however. The fact that the labour share only began to decline after the crisis is not easy to square with the intangible story. Other channels that raise markups of price above cost in times of stagnation call for further investigation. See Autor, et al., (2017) for a recent discussion of the US case.[111]

4.2 Multifactor productivity

Multifactor productivity is part of the growth of output not explained by growth in inputs. Over long spans of time, productivity growth is the most important component of overall earnings growth. It accounted for most of the growth in the earlier period, except in Italy and Spain. Table 3 compares the growth of multifactor productivity in the two periods. None of the six countries considered here had satisfactory average growth rates in the seven post-crisis years, and three of them suffered productivity shrinkage. Poor productivity growth is a major contributor to stagnation.

Table 3

Average Annual Growth of the Log of the Labour Share in the Pre- and Post-Crisis Years

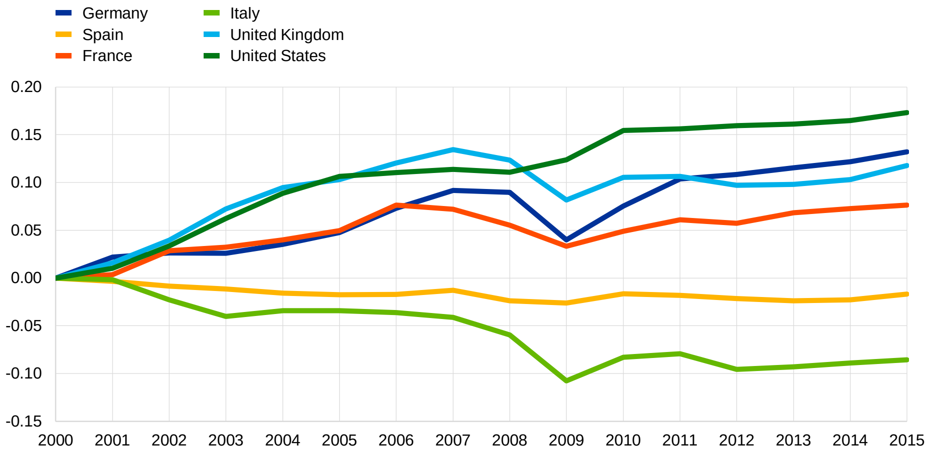
(percentages)

Country	2000-2007	2007-2014
Germany	1.53	0.50
Spain	-0.21	-0.17
France	1.20	0.01
Italy	-0.69	-0.80
UK	2.24	-0.52
US	1.90	0.85

Figure 3 shows the annual evolution of the log of multifactor productivity. In all six countries, productivity fell or its growth declined immediately after the crisis. Spain and the US had the smallest shortfalls at that time. Productivity growth in Germany, France, and the US has resumed in more recent years, but not at pre-crisis rates. In the other three countries, essentially no growth has occurred in productivity, except for recent growth in the UK.

[111] Autor, David, Dorn, David, Katz, Lawrence F., Patterson, Christina, and Van Reenen, John (2017), "The Fall of the Labor Share and the Rise of Superstar Firms", Cambridge, Mass., USA, *National Bureau of Economic Research Working Paper* 23396, May.

Figure 3
Log of Index of Multifactor Productivity



Fernald, Hall, Stock, and Watson carry out an analysis of the low rate of productivity growth in the US since the crisis. The rapid growth of productivity from 1995 to 2006 was likely the result of rapid adoption of information technology — such as the relational database — in many sectors, notably retail trade. Adoption may have slowed down. The heterogeneity in productivity growth among the six countries both before and after the crisis creates a challenge for technology-based explanations of productivity — advanced countries share access to new technologies widely. Other hypotheses about the slowdown in the US, such as a rising burden of regulation, remain plausible but are not supported by the limited data available.

4.3 Capital/Output ratio

Table 4 compares the growth of the capital/output ratio in the two periods. Capital is the stock of plant, equipment, and intellectual property. Though flows of capital formation have generally been weak in advanced countries, the table shows that the growth of capital relative to output increased in four of the six countries and declined only slightly in the other two, Germany and the US.

Table 4

Average Annual Growth of the Log of the Capital/Output Ratio in the Pre- and Post-Crisis Years

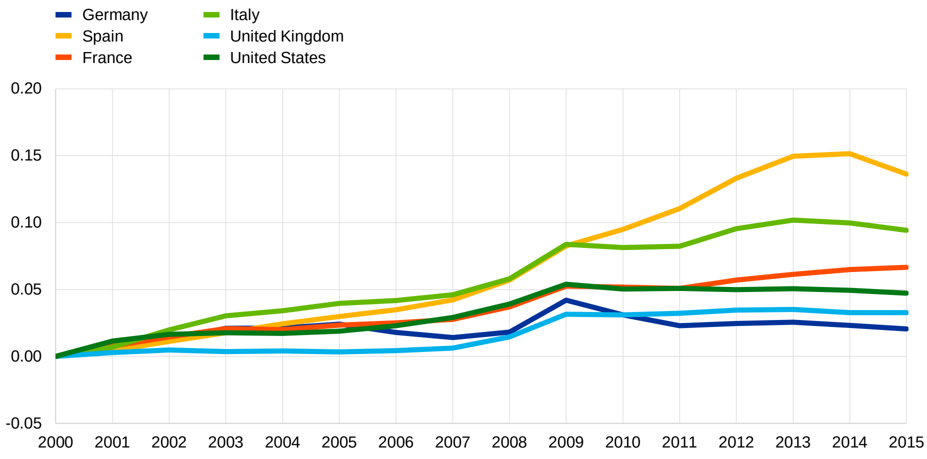
(percentages)

Country	2000-2007	2007-2014
Germany	0.24	0.15
Spain	0.70	1.82
France	0.46	0.62
Italy	0.77	0.89
UK	0.10	0.44
US	0.49	0.34

Figure 4 shows the annual evolution of the log of the capital/labour ratio. The ratio grew at similar moderate rates among the six countries through 2007, then jumped upward. The jump was the result of declining output, not a leap in capital formation. In countries with recoveries in output, the ratio fell back to its previous growth path. Spain and Italy, the countries most afflicted with output stagnation, saw further increases in the capital/output ratio.

Figure 4

Log of Index of Capital/Output Ratio



Weak capital formation is often cited as an aspect of stagnation. But it is a result of other forces of stagnation, in the sense that investment theory emphasizes that investment flows tend to stabilize the capital/output ratio, while raising the capital stock and raising the capital/labour ratio. The finding of stable and rising capital/output ratios shows that low productivity and declining labour-force participation, together with other adverse influences, lowered output growth and hence caused declining capital formation.

4.4 Weekly hours

Table 5 compares the growth of weekly hours per worker in the two periods. Figure 5 shows the annual evolution of the log of weekly hours per worker. It is close to proportional to the total hours of work in a year divided by the average number of people at work over the year. It is the number of hours the typical worker would put in if employed throughout the year.

Table 5

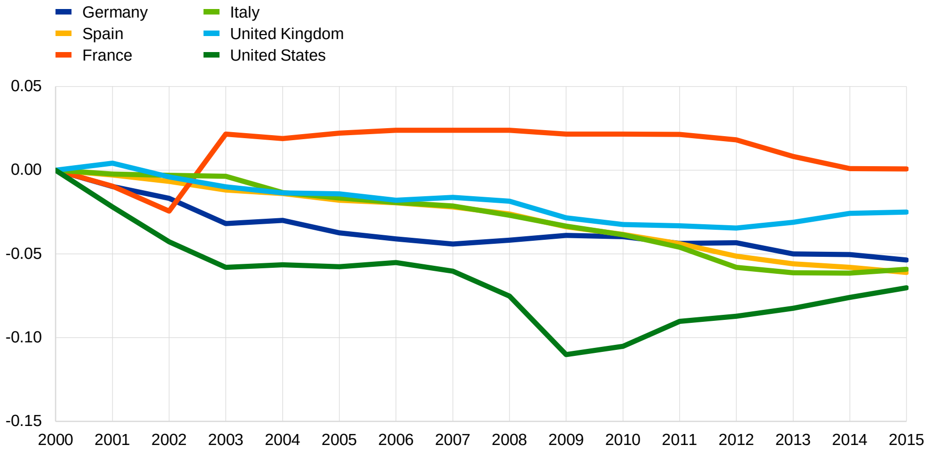
Average Annual Growth of the Log of Weekly Hours per Worker in the Pre- and Post-Crisis Years

(percentages)

Country	2000-2007	2007-2014
Germany	-0.73	-0.11
Spain	-0.37	-0.60
France	0.40	-0.38
Italy	-0.36	-0.67
UK	-0.27	-0.16
US	-1.01	-0.26

Figure 5

Log of Index of Weekly Hours per Worker



Hours trended downward in all six countries over the entire period from 2000 to 2014. The decline in hours after the crisis was a substantial contributor to the decline in those years in total real earnings per member of the population in Italy and Spain. These are the countries with the largest and most persistent increases in unemployment, so it would appear that increases in unemployment and decreases in hours respond to the same forces.

4.5 Employment rate of the labour force

Table 6 compares the growth of the log of the employment rate of the labour force in the two periods. Recall that this variable is log(1-u), where u is the unemployment rate stated as a decimal. In some economies, notably the US and the UK, the employment rate tracks the business cycle closely, rising in booms and falling in recessions. Because the employment rate returns fairly quickly to its normal level after a shock, its average over seven-year periods is close to normal, as shown in the table. In continental European countries, other factors are important, so the table has large positive figures for Italy and Spain during the earlier period and for Germany in the later period, and large negative figures for Italy and Spain in the later period. For these countries, those negative figures make important contributions to their declines in earnings. France had a moderate contraction in its employment rate in the later period.

Table 6

Average Annual Growth of the Employment Rate of the Labour Force in the Pre- and Post-Crisis Years

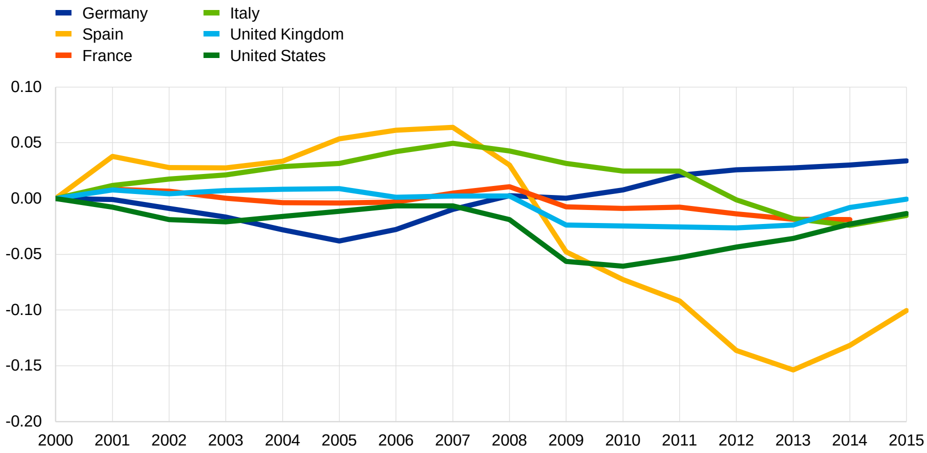
(percentages)

Country	2000-2007	2007-2014
Germany	-0.16	0.66
Spain	1.06	-3.26
France	0.08	-0.40
Italy	0.83	-1.23
UK	0.04	-0.17
US	-0.11	-0.27

Figure 6 shows the annual evolution of the log of the employment rate of the labour force. In all countries except Germany, a bulge of unemployment occurred immediately after the crisis in 2008. The bulge was largest for the US, where the employment rate fell by five percentage points, then recovered most of the decline by 2014 (and all by 2016, not shown). The decline and recovery in the UK employment rate was similar, but the amount of the decline was less than half that of the US employment rate. In France, no recovery occurred after the initial bulge — rather, the employment rate drifted downward. It would be hard to generalize about the responses of the employment rates of the four continental European countries.

Figure 6

Log of Index of the Employment Rate of the Labour Force



4.6 Labour-force participation rate

The labour-force participation rate is the fraction of the working-age population who are looking for work or who are working. Table 7 compares the growth of the rate in the two periods. In the earlier period, participation grew in four countries, especially in Spain (but not much in Italy). It was close to steady in France and the US. In the post-crisis period, participation grew by small amounts in five countries but shrank significantly in the US.

Table 7

Average Annual Growth of the Labour-Force Participation Rate in the Pre- and Post-Crisis Years

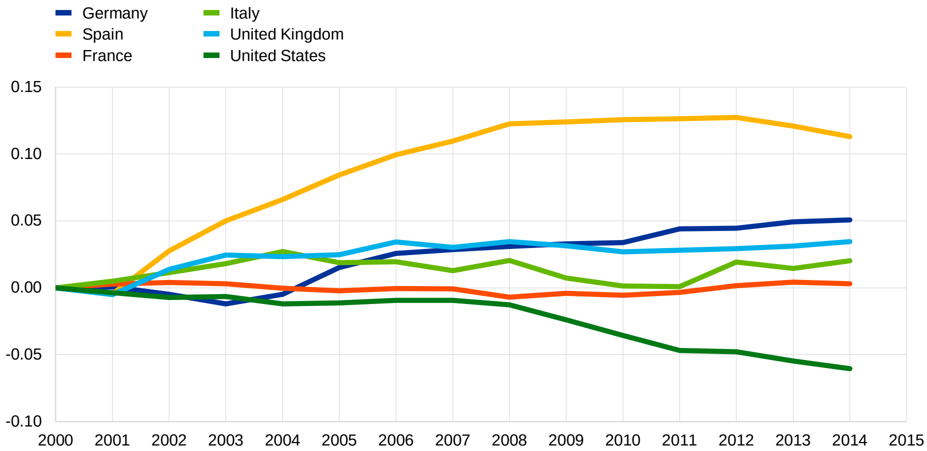
(percentage points)

Country	2000-2007	2007-2014
Germany	0.47	0.37
Spain	1.83	0.05
France	-0.02	0.07
Italy	0.21	0.12
UK	0.50	0.07
US	-0.16	-0.85

Figure 7 shows the annual evolution of the log of the labour-force participation rate. Spain and the US are conspicuous outliers. The post-crisis decline in US participation has received a great deal of attention. Though the decline began around the time of the crisis, most of it appears to be the result of noncyclical forces. One of these is demography — the large baby-boom cohort began to retire over this period. This factor accounts for about a third of the total decline. From 2010 through 2014, as unemployment returned to normal, participation continued to decline.

Figure 7

Log of Index of the Labour-Force Participation Rate



4.7 Ratio of working-age population to total population

Table 8 compares the growth of the ratio of working-age population to total population in the two periods. This component accounts for children who are dependent on earners. Figure 8 shows the annual evolution of the log of the ratio. In the post-crisis period, only the US had a change in the ratio that was material, and it was fairly small but favourable.

Table 8

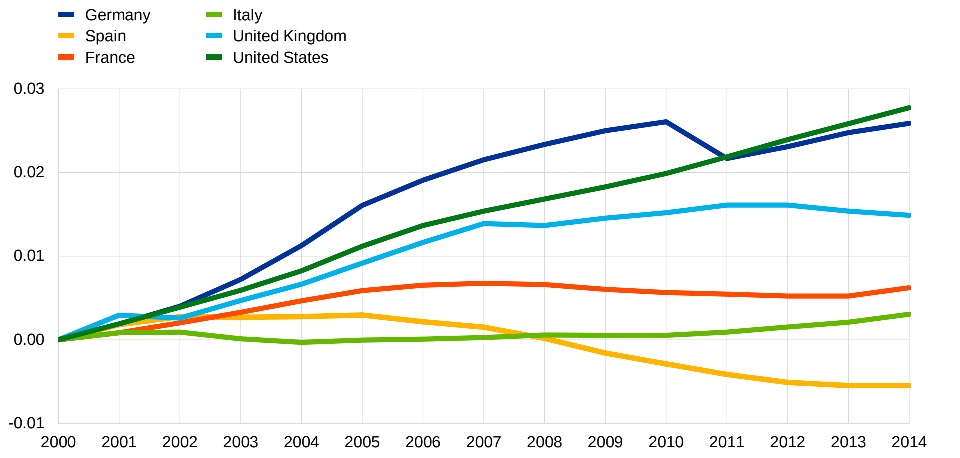
Average Annual Growth of the Ratio of Working-Age Population to Total Population in the Pre- and Post-Crisis Years

(percentages)

Country	2000-2007	2007-2014
Germany	0.36	0.07
Spain	0.02	-0.12
France	0.11	-0.01
Italy	0.00	0.05
UK	0.23	0.02
US	0.26	0.21

Figure 8

Log of Index of the Ratio of the Working-Age Population to Total Population



5 Conclusions

The six countries have access to the same technologies, have economic advisors trained at the same universities, have professional elites who all can speak the same language, and have tightly integrated capital markets. They all elect governments with reasonably limited involvement in their economies — mainly in the form of generous redistributional programs. They rely on private economic actors to manage production, employment, and investment, subject to moderate regulation. They have no obvious sources of idiosyncratic shocks. They were all hit by a similar shock that resulted in steep drops in equity prices and in under-capitalized banks.

But even before the crisis, macroeconomic outcomes in these countries varied tremendously. Growth in real earnings per person was spectacular in the UK, mediocre in France, Italy, Spain and the US, and negative in Germany. Productivity growth was close to longer run historical levels in France, Germany, the UK, and the US, but negative in Italy and Spain. Unemployment fell dramatically in Italy and Spain but was stable in the other four countries. Labour-force participation grew a lot in Spain, moderately in Germany and the UK, and was essentially unchanged in the other three countries.

Heterogeneity in performance after the crisis was even greater. Real earnings per person grew from 2007 through 2014 by almost two percent per year in Germany and by 0.7 percent per year in France, but fell in the other four countries, especially Italy and Spain. The share of national income accruing to workers fell, in four cases dramatically, in all countries but Germany. Productivity growth was sub-par in all six countries, but positive in Germany and the US and negative in Italy and Spain.

Table 9 distills the figures for the major components, with shades of green indicating favourable positive values and red for unfavourable negative values. The figure reinforces the conclusion that the outcomes are heterogeneous. Germany comes out as the least stagnated and Italy and Spain as the most stagnated.

Table 9

Summary of Post-Crisis Components

	Share	Productivity	Hours/week	Employment rate	Participation
Germany	0.28	0.50	-0.11	0.66	0.37
Spain	-1.50	-0.17	-0.60	-3.26	0.05
France	-0.93	0.01	-0.38	-0.40	0.07
Italy	-1.04	-0.80	-0.67	-1.23	0.12
UK	-0.35	-0.52	-0.16	-0.17	0.07
US	-0.85	0.85	-0.26	-0.27	-0.85

Notes: shaded green for positive and red for negative.

The column with the highest frequency of adverse scores is the labour share, which is negative for all countries but Germany. If market power obtained from inefficient concentration is responsible for the declining labour share, then that decline is a form of stagnation — a development that cuts real income persistently. On the other hand, if the decline comes from a shift in the product mix toward products with high ratios of price to marginal cost — tech products, entertainment, pharmaceuticals — then including their negative effects on the labour share as part of stagnation may be going too far. Economists have often proposed that the government should buy out the intellectual property rights to high-priced drugs and then set the price to the marginal cost of production. By the same logic, the government should buy out the rights to the iPhone and sell it for $135.

Immediately after the crisis, when unemployment rose in many countries, including all six considered here, economists treated impending stagnation as an issue of deficient demand, arising from the inability of monetary policy to restore full employment by cutting interest rates far enough. Central banks' abilities to offset the effects of the crisis on demand were limited by the effective lower bound on interest rates. Huge fiscal deficits stood in the way of meaningful fiscal expansion. Two of the components of real earnings studied here — the employment rate and hours of work per week — are cyclical indicators in the US. Figure 5 shows a hint of a cyclical response of hours in the UK, but not in the four continental countries. Figure 3 shows cyclical declines with quick rebounds in multifactor productivity in all countries but the US. Figure 7 shows no sign of a cycle in labour-force participation triggered by the crisis in any of the six countries. In summary, the demand-related movements of the components seem to be quite limited. In the cases of Italy and Spain, where unemployment remained high through 2014 (and after), the possibility remains that lingering high unemployment could be cured by country-specific demand policies.

One idea about stagnation that links earlier shortfalls in demand to later levels of output is through investment. Weak investment cumulates to shortfalls in the capital stock in later years. It is true that, if the level of investment spending had remained at pre-2008 levels, the capital stocks in the six countries would have been higher in the post-crisis years, with the possible exception of Germany.

Stagnation shows through strongly in the data — real earnings per member of the population has grown much less or has even shrunk in the aftermath of the crisis. In thinking about the anatomy of stagnation, attention has shifted to stagnation in components that do not usually respond to fluctuations in demand — sometimes called supply components. In the US, for example, the two big components of stagnation are the declining labour share and declining labour-force participation. The first is not obviously related to supply, while the second is an aspect of labour supply. In recent years, productivity growth has been a third component of US stagnation. A better way to divide the components into two groups would be to ask which ones would respond to monetary or fiscal expansion — the demand components — and those that do not respond — the other components.

In some countries, the employment rate and weekly hours would be under the influence of demand, notably the US. The most seriously stagnated countries among the six considered here are Italy and Spain. It is an open question how much of their excess unemployment would yield to monetary or fiscal expansion.

I believe this paper makes it quite clear that unitary theories of stagnation are unhelpful in studying the behaviour of advanced economies since the crisis. Rather, each country has its own story, involving economic models of factor shares, productivity growth, unemployment, labour supply, and demographics. The great puzzle is how there can be so much heterogeneity in the stories, among countries that appear to be basically similar and were responding to similar shocks over the post-crisis period.

The primary lesson for economic policy in the findings of this paper is the importance of financial stability. All six countries studied here suffered from the paralysis of monetary policy from the effective lower bound, a direct result of the panic associated with the financial crisis. Advanced countries with stable financial systems and independent monetary policy, such as Canada, performed better during and after the financial crisis.

The basic principles of financial regulation to create shock-proof financial systems were well understood prior to the crisis, but supervision failed badly in many jurisdictions. Under the implicit protection of central banks and national governments, financial institutions took on far too much risk, making them vulnerable to shocks from declining real-estate prices and from other sources. Under the guidance of proper stress tests, bank regulators would have prevented instability, and under proper non-governmental resolution principles for insolvent institutions, investors would have disciplined excessive risk exposures and eliminated the temptation of the free government put.

6 Appendix

Let y be the log-change in output, A be the log-change in total factor productivity, n be the log-change in labour input, k be the log-change in capital, and α be the elasticity of the production function with respect to capital. Then the production function is, in log changes,

$$y = A + (1-\alpha)\,n + \alpha k.$$

$$y - n = A + \alpha\,(k - n)$$

$$= A + \alpha\,(y - n) + \alpha\,(k - y).$$

So

$$y - n = \frac{A}{1-\alpha} + \frac{\alpha}{1-\alpha}\,(k - y)$$

Comment on “Sources and Mechanisms of Stagnation and Impaired Growth in Advanced Economies” by Robert Hall

By Gauti B. Eggertsson[112]

1 Introduction

This paper has a very useful growth accounting of labor income in 6 advanced industrialized economies. It offers an important basis for accounting for income growth in the past 14 years, but the latter half of this period is increasingly being identified with stagnation. This discussion is organized as follows. First, I highlight two stylized facts based on the paper. Then I discuss the core of the work which is labor income growth accounting. This decomposition splits the growth in real labor income into 7 different components. I present the decomposition in a slightly different way than Hall does in his paper. I then discuss interpretations and suggest that modern New Keynesian theory can be quite helpful in understanding what is going on. There I highlight some disagreement I have with Hall about the source of the slowdown in growth arguing that demand may have accounted for more than he suggests.

2 Hall’s stylized facts

The term “stylized fact” was invented by the macroeconomist Nicholas Kaldor, because in macroeconomics we never have firm facts. Instead, we observe broad tendencies. There always seem to be exceptions to the overall pattern, hence the qualifier “stylized”. I would like to propose two stylized facts based on Hall’s paper.

2.1 Stylized fact #1

The Great Recession marked a strong fall in labor per capita, shown in Figure 1 in Hall’s paper. Importantly, this figure is income per member of the population. It has been falling or growing slower ever since the economic crisis started in 2008. One of the things Hall emphasizes is that the performances of the six countries he considers are quite different, especially across France, Germany, Italy and Spain. He suggests that an implication of this is that no unitary theory is useful to think about this stylized fact. My theme is somewhat counter to that. My reading is that all six countries were subject to a crisis shock, or what I will term as a fall in the natural rate of interest.

[112] Brown University.

The thing that explains the different outcomes is that each of the EURO countries (France, Germany, Italy, Spain) was hit to a different extent, with Germany being the least affected. Yet, they were forced to have a single monetary policy. New Keynesian theory then predicts we should observe very different outcomes across these four counties. Meanwhile, UK and US had their own monetary policy. Accordingly, the recessions in those countries was not quite as bad as the worst hit European countries. If one plots up the average income growth in the Eurozone and compares to US and UK, the patterns look a bit more similar across the countries than Figure 1 implies, more on this at the end of the comment.

2.2 Stylized fact #2

A large part of the fall in labor income can be explained by a fall in the share of income that goes to labor or what we term labor share. This appears to apply to all countries with the exception of Germany[113]. Here we see that this drop becomes more severe right around the crisis.

3 Hall's labor income growth accounting

How can we account for the drop of income per member of population? The key innovation of the paper is to propose a simple and useful accounting framework, akin to growth accounting. Relatively to typical growth accounting, the main innovation is to go into much more detail in the volume of labor input, L_t, and allowing for time-varying share that goes to labor income, α_t.The decomposition works as follows: the volume of labor in the economy, L_t, is drawn from the total population, N_t, of which only a fraction is of working age, H_t/N_t. Out of H_t, however, only a fraction are a member of the labor force, i.e. either working or looking for work, F_t/H_t. Next, out of labor force, F_t, only a fraction is employed, e_t. Finally, for every person employed, there may be variations in how many hours every employed worker works in the workforce, h_t. Accordingly, we can decompose labor input changes into these 4 different margins: variations in working age of the population, labor force participation, employment/unemployment rate, and hours work per working member.

Then Hall takes account of the share of income that goes to labor. If we assume Cobb Douglas production function, $Y_t = A_t K_t^{1-\alpha_t} L_t^{\alpha_t}$, that would be given by α_t, but here A_t is total factor productivity (TFP) and K_t is capital. Hall takes account of the contribution of capital accumulation in his decomposition, which he shows can be captured by the capital output ratio K_t/Y_t, and finally, total factor productivity A_t. This is a simple and useful way to look at the data. As with all good ideas one wonders why it has not been done before.

The Hall labor income decomposition has a very nice interpretation. Let us say that the income growth per member of population over a few years is 1 trillion. Then we

[113] One thing that is a little bit of a puzzle to me, compared to other papers presented in the conference, is the absence of any fall in labor share in Germany. This might be worth looking further into.

can, as a matter of accounting, decompose it into: change in labor inputs, i.e. (i) working age to total population, (ii) labor force participation, (iii) employment rate, and (iv) hours per worker. Change in capital input given by the (v) capital output ratio. Change in (vi) total factor productivity. And finally change in (vii) the labor share. The point is that these growth rates should all sum up to the total. This suggests a natural way to visualize Hall's accounting results which I do below for each of the 6 countries. I can take no credit for the numbers, I am simply reporting Hall's income accounting results that he generously shared with me prior to this conference.

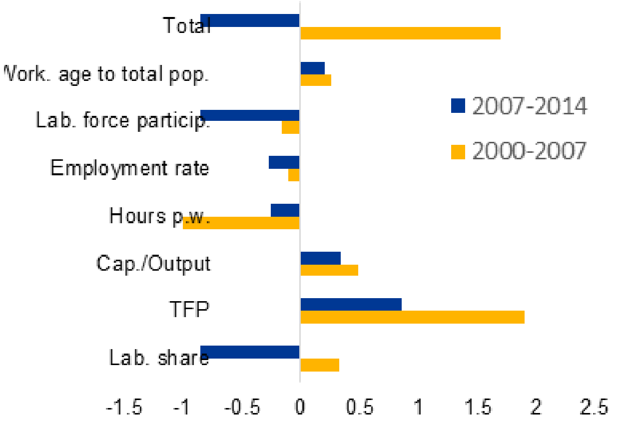
In blue color is the period 2007-2014, in orange color the period 2000-2007 for the US in Chart 1. We see on top the total income growth measured in annualized growth rates. Labor income grew in 2000-2007 by a 1.7 percent per year, while it fell in the period 2007-2014 and contracted by about 0.8 percent per year. These two numbers are represented by the two top bars. Below the two bars, we see decomposition of the overall growth rates into the 7 different contributing factors, all of which sum up to the total[114]. For the US the largest part of the drop in labor income is explained by the decline in labor force participation as well as the fall in the labor share. We also see that the slowdown in TFP growth played a significant role, even if it did not dip into negative territory. To sum up for the US, the three main factors playing the biggest role appear to be the fall in labor force participation, decline in labor share and slower growth of TFP. Declines in employment rates, capital accumulation and working age play a smaller role in accounting for the slower growth in labor income.

Moving to Spain in Chart 2, we also see a sharp turn from growth in labor income in 2000-2007 to contraction in 2007-2014. Explaining this is again a decline in the volume of labor as in the case of the US. But this fall in the volume of labor is not due to a fall in labor force participation as in the US. Instead it is due to a fall in the employment rate and to some extent hours per worker. The second main element is a fall in labor share. TFP is not doing a whole lot in Spain to account for the fall in labor income growth, in contrast to the US.

[114] While the 7 factors should sum up to the total, there is a discrepancy. This is because the data are not compiled exactly in the same way as the theory. Sorting out the source of the difference is a topic for future research.

Chart 1

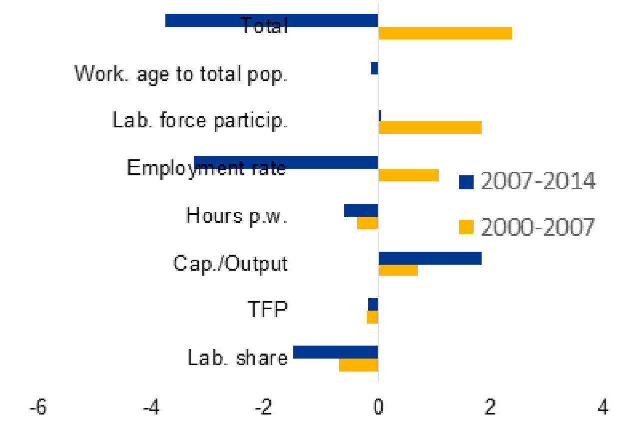
Labor income growth per capita: United States



Sources: Hall (2017).

Chart 2

Labor income growth per capita: Spain



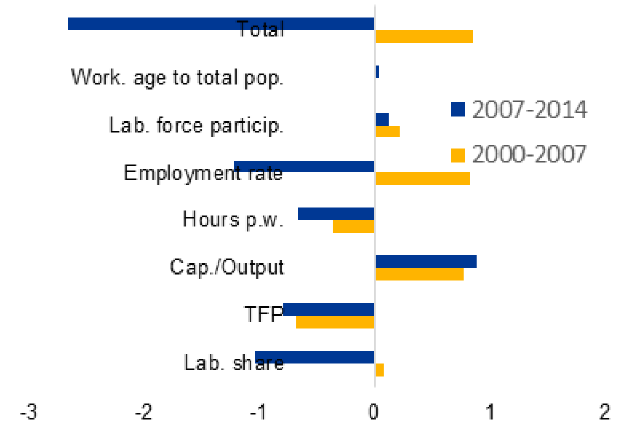
Sources: Hall (2017).

Moving to Italy in Chart 3, again there is sharp difference in overall developments in two periods, with modest income growth in the period 2000-2007 being replaced by a contraction. Again, we also see the volume of labor input falling. But here it is a combination of the employment rate and hours worked. Again the labor share is declining. As in the case of Spain, we do not see much going on in TFP. Note the difference in scale for Italy vs. Spain, the fall in income is bigger in Spain.

As seen in Chart 4, France is somewhat similar to Italy and Spain, even if the fall in real labor income is smaller. Again you see that the volume of labor is the factor contributing the most to the decline in income. In this case it is both the employment rate and hours per worker. Yet again labor share was falling. You do see analogies here in US, Italy, Spain and France: Fall in labor input and contraction in labor share. The key difference is what measure of labor input is falling.

Chart 3

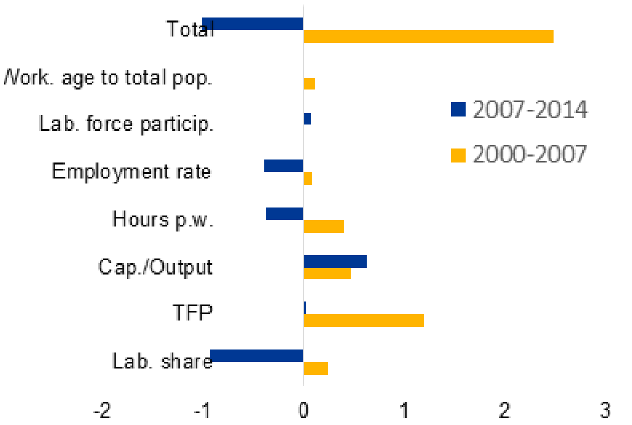
Labor income growth per capita: Italy



Sources: Hall (2017).

Chart 4

Labor income growth per capita: France



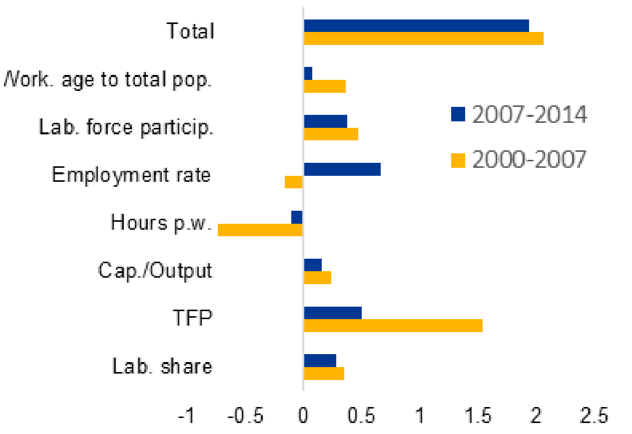
Sources: Hall (2017).

The last member of the Eurozone that is accounted for is Germany. Here we can see that there appears to be little stagnation in income growth. As I had already mentioned, I think one explanation is that Germany, Spain, Italy and France were constrained to have the same monetary policy during this time period even if they were hit differently by the financial crisis. Under this interpretation the policy by the ECB was consistent with full utilization of labor inputs in Germany, but not so in the other EURO countries, especially in Italy and Spain. It is thus the combination of asymmetric demand shocks and a single monetary policy that explains the different outcomes.

Perhaps a bit of an odd man out here is UK shown in Chart 6, at least in terms of the decomposition. As in the other countries, with the exception of Germany, we see a dramatic move from labor income growth to stagnation in the aggregate numbers. The decomposition differs, however. What seems to be driving the slowdown in labor income appears to be primarily the fall in TFP rather than in any measure of labor input (even if we also see a decline in the labor share here). One interpretation of the UK is that with its independent monetary policy it did more to offset the shock than the other countries. One indication of this is that inflation did not significantly undershoot in the UK, in contrast to the other stagnating economies. More than any of the other countries, however, UK was a financial center that was seriously hit by the crisis. Perhaps one should then not be too surprised to see the crisis spilling into TFP.

Chart 5

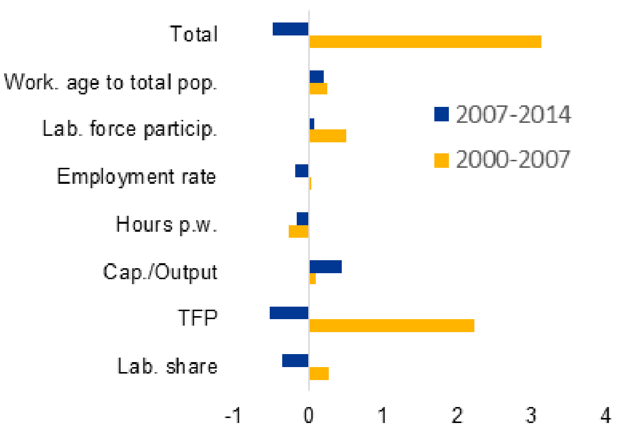
Labor income growth per capita: Germany



Sources: Hall (2017).

Chart 6

Labor income growth per capita: UK



Sources: Hall (2017).

4 What have we learned from Hall income accounting?

It is by no means a criticism to say that I think the numbers presented above will probably not be the final word on accounting for differences in labor income growth in this period in the six countries. Behind these calculations are a lot of data and institutional details, all of which will be subject to increased scrutiny and revision in coming years. The evidence above, therefore, is only suggestive at this stage. The discussion above, however, gives an idea of the kind of questions Hall's labor income accounting can address. Let me highlight a few things I think we have learned. Perhaps the most useful thing to highlight is what factors we can exclude as candidates in explaining the stagnation in labor income. First, aging does not account for much. The contribution of the decline in the working age to total population is not too important in any of the countries. The aging story is one popular narrative to explain stagnation, and this is suggesting that aging is not driving the drop in the volume of labor input in any of the 6 countries[115]. Second, lack of investment is not the story. In none of these countries can a fall in capital to output account for much. Low investment, perhaps due to financial frictions that applied with greater force than normal in the crisis, is one popular narrative for the sluggish income growth since 2007. Hall's labor income accounting does not support this hypothesis. Finally, it is common to think of TFP as an important driver of variation in income over time. TFP tells no consistent story across these 6 countries. It appears to be all over the map.

So what is the story? Let me offer two observations. First, France, Italy and Spain all see a drop in labor input, via employment rate and hours worked. In US, however, this shows up as drop in labor force participation. Why does the drop in labor input show up differently in US vs. EU countries during this stagnation period? Many have suggested that the fall in labor force participation in the US is unrelated to the crisis. I am skeptical of this viewpoint. If the fall in labor participation was unrelated to the crisis, then why did labor participation not also fall in other advanced economies? The sharp steep drop in labor participation right around the crisis seems too stark to be chalked out as a coincidence. I think a more reasonable interpretation is that labor input fell in all four countries for the very same reason: it was a response to an aggregate demand shock, that ultimately had its roots in the financial crisis (e.g. due to a debt deleveraging shock as in Eggertsson and Krugman (2012) or shock to liquidity of financial assets as in Del Negro, Eggertsson, Ferrero and Kiyotaki (2017). But this demand shock affected labor input differently in different countries. Why? Let me suggest that the reason is different labor market institutions. In any event, this is a key question to be debated. Second, all countries except Germany have a fall in labor share, violating a key Kaldor fact. What is the driver of this? This is a wide open question, for which I do not have much concrete suggestions for. I have long thought that in the US it had something to do with an increase in monopoly power of firms. But given the fall in labor share in Europe mirrors quite closely what happened in the US, is it a reasonable explanation? I have heard many argue that an increase in monopoly power of firms is a hard story to tell in Europe during this conference. Let me also suggest that it seems somewhat hard not to suspect that this fall had something to do with the large demand shock observed in 2008. Yet, I am not aware of any theory that accounts for this pattern working through aggregate demand.

[115] Work such as Eggertsson and Mehrotra (2014) has suggested that aging could instead lead to demand stagnation by driving down the natural rate of interest. There is nothing in the decomposition that is inconsistent with that idea, as it works through aggregate savings.

5 Differences in interpretation

I have so far highlighted Hall's labor income accounting and how I interpret it. It seems only fair to highlight, however, that my own interpretation is quite a bit different from Hall's. I view this more as a feature than a flaw of his suggested accounting framework. It is a tool for representing the data rather than a structural method that gives concrete conclusion. Hall proposes that the first stylized fact is most plausibly explained by supply than demand factors. He appears to base this assessment to a large extent on the fact that the employment rate (or unemployment) has recovered to pre-crisis level in both the US and the UK. I think it is worth emphasizing, however, that there is no theoretical reason why slack demand has to show up only via only this one measure of labor input, that is employment rate. I see no reason why low demand cannot also show up in lower labor participation or hours worked. Indeed, as I have already suggested, perhaps "labor rationing" in response to subpar aggregate demand is just happening via different mechanisms in different countries depending on different labor market institutions. Furthermore, there seems no reason to believe that demand cannot show up in TFP as shown for example in Garga and Singh (2017) via mechanisms of endogenous innovation.

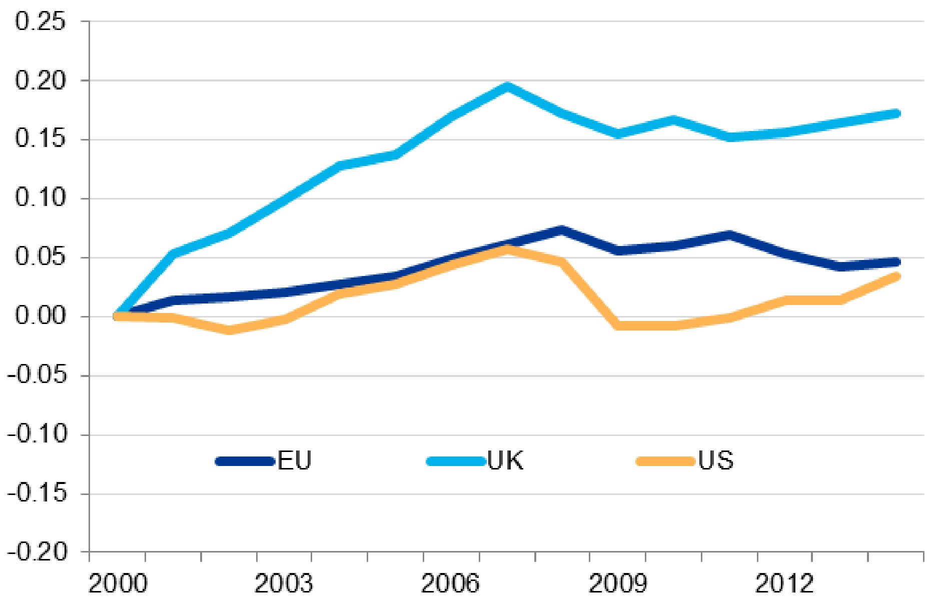
The bottom line is I do not see anything here in the results that suggests that the slowdown in income growth during this period was not driven by aggregate demand. It remains the prime suspect in my mind due to the financial crisis. Does this matter? Yes, because if we say that demand is not driving the subpar income growth, we give monetary policy a free pass. I think this would be a big mistake, especially here in Europe. Also, it ignores the obvious thing that these countries all have in common. What is it? Or put it differently: what does theory predict we should expect in a demand driven recession? New Keynesian theory, see e.g. Eggertsson and Woodford (2003), models a demand shock as a decline in the natural rate of interest, that is, the real interest rate for all resources to be fully utilized. Later literature established that this drop could either be modeled as household debt deleveraging shocks, or stemming from turbulence in the banking sector (see e.g. Benigno, Eggertsson and Romei (2014). Meanwhile, Eggertsson, Mehrotra and Robbins (2014) show that there is no reason to expect this shock to revert quickly, or even at all (what has been termed the secular stagnation hypothesis, see Summers (2017) and see Eggertsson, Mehrotra, Singh and Summers (2017) for an international perspective). What is the prediction of a demand shock that leads the natural rate of interest to be negative? The key prediction is i) nominal interest rate collapse to zero, ii) inflation undershoots its target and iii) output is below potential (and accordingly labor income growth should be expected to be subpar). Let me suggest to you that what we observe in the data in these 6 countries is consistent with i)-iii).

6 Conclusions

The figure below summarizes Figure 1 in Hall's paper slightly differently. It shows the labor income growth in the EURO zone aggregating together France, Germany, Italy, Spain with a blue line. It compares it to the two other currency areas Hall considers, i.e. US and the UK. Hall's stylized fact #1 now seems more apparent even to an extent one does not need the qualifier "stylized" anymore. Labor income growth per capita slowed down markedly around the crisis across these three currency areas. It still seems anemic. Taken as a whole the EURO area does not look all that different to the US or UK. The different outcomes in Germany vs. France vs. Italy vs. Spain are then most plausibly explained by the fact that they got very differently hit by the financial crisis. Yet, they were forced to adopt a single monetary policy. This unitary demand theory then explains why Spain did so much worse than Germany. At the heart of it is a common demand shock tied to the financial crisis and nominal frictions in the New Keynesian tradition. The theory also gives a natural explanation for the anemic growth. The story is simply that none of these economies could cut the real interest rate sufficiently to accommodate the shocks due to the zero lower bound. Stories about the anemic growth, i.e. why recession lasted for so long and why the recovery was so week, then become stories about why the shock was so persistent. The literature on secular stagnation, see e.g. Eggertsson, Mehrotra and Robbins (2017), fleshes out these type of stories theoretically and quantitatively. I think they do a reasonable job. Therefore, I do not think we need to throw up our hands and say that no unitary theory of these developments is useful. We have that theory.

Chart 7

Real Compensation per Member of the Population



Sources: Hall (2017).

If one adopts this perspective, as I do, Hall's decomposition does pose several serious challenges. One challenge is to explain why slow growth showed up in lower labor force participation in US, but instead in lower employment rate in the EURO area. Different labor market institutions might be helpful here. A second challenge is to explain the very different behavior of TFP across the different countries and especially if it can be modeled as driven by the demand shock. Recent work on hysteresis effects may be of help here, see e.g. Garga and Singh (2017). A third challenge is that Hall clearly documents a fall in labor share in all countries above, with the exception of Germany. I think we still do not have a good theory of what is driving this.

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On the interaction between monetary policy, corporate balance sheets and structural reforms[116]

By Philippe Aghion[117], Emmanuel Farhi[118], Enisse Kharroubi[119]

Abstract

In this paper, we use cross-industry, cross-country panel data to test if, and how monetary policy can affect growth. To do so, we use two alternative approaches. We first focus on the reactivity of real short term interest rates to the business cycle and show that its interaction with industry-level measures of financial constraints correlates positively and significantly with industry-growth. Yet, this effect holds only in countries with a relatively low index for product market regulation. When product markets are severely regulated, the cyclical pattern of real short term interest rates has no impact on industry growth. Second, we compute the unexpected drop in long-term government bond yields of Euro Area countries that followed the ECB's announcement of Outright Monetary Transactions (OMT) and show that it raised growth disproportionately more in highly indebted sectors. Moreover, this effect holds only in countries where the product market regulation index is rather low. Otherwise, the drop in government bond yields had either no effect or benefited to less indebted sectors.

1 Introduction

To explain the resilience of the American economy compared to the European economy following the crisis of 2007-2009, some economists (e.g. see Mahfouz and Pisany-Ferry, 2016) have blamed the lack of macroeconomic reactivity in Europe, while others have pointed to the failure or delay by European nations, to implement badly needed structural reforms. In this paper we shall argue that the lack of macroeconomic reactivity as well as the persistent rigidities on the goods markets, have inhibited growth in Europe.

This opinion echoes the words of Mario Draghi, the President of the European Central Bank (ECB), who declared at the 2014 Economic Policy Symposium in Jackson Hole that he could only do half the work by relaxing monetary policy and

[116] The views expressed here are those of the authors and do not necessarily represent the views of the BIS.

[117] Collège de France, London School of Economics, and CEPR.

[118] Harvard University and NBER.

[119] Bank for International Settlements.

that Member States would have to do the other half by implementing structural reforms. Thus Mario Draghi pointed to the complementarity between proactive monetary policies on the one hand and accelerated structural reforms in the labour and product markets in order to boost growth and reduce unemployment. In this paper we use cross-country and cross-sector panel data to argue that a more pro-active monetary policy is more growth-enhancing in a more competitive environment.

In the first part of this paper we develop a simple model in which firms can make growth-enhancing investment but are subject to liquidity shocks that forces them to reinvest money in their project. Anticipating this, firms may have to sacrifice part of their investment in order to secure reinvestment in case of a liquidity shock (liquidity hoarding). A countercyclical monetary policy, which sets high interest rates in expansions and low interest rates in recessions, turns out to be growth-enhancing as it reduces the amount of liquidity entrepreneurs need to hoard to weather liquidity shocks. Moreover, our model predicts that a more countercyclical monetary policy is more growth-enhancing when competition is high: indeed when competition is low, large rents allow firms to stay on the market and reinvest optimally, no matter how funding conditions change.

We use two alternative empirical approaches to test this prediction. First, we regress long-term industry growth on the cyclicality of monetary policy interacted with a measure of industry financial constraints. There, we focus on the cyclical pattern of real short-term interest rates and find that it is growth-enhancing at the industry level, and the more so in industries facing tighter credit/liquidity constraints. Interest rate rules inducing lower real short term interest rates in recessions but higher short-term interest rates in expansions, are hence more growth-enhancing for sectors that face either tighter credit constraints or tighter liquidity constraints. But separating our sample of countries between those with tightly regulated product markets and those relatively unregulated product markets, we find the growth enhancing effect of monetary policy applies only in the latter countries while both the magnitude and the statistical significance of this effect are much reduced in the former countries. The growth-enhancing effect of countercyclical monetary policies hence only derives from the experience of countries that are more competitive (where competition is measured inversely by the OECD\ indicator of barriers to trade and industry).

Second, we regress long-term industry growth on the fall in long-term government bond yields following the ECB policy response in the form of Outright Monetary Transactions (OMT) interacted with product market competition. There, we focus on the unexpected drop in long-term government bond yields following the announcement of OMT – and show that thereafter industry growth was higher in more indebted sectors whenever government bond yields had fallen by more. Heavily indebted sectors therefore benefited disproportionately more from the drop in long-term government bond yields following OMT. However, as was the case in the first approach, falling government bond yields helped only insofar as product market regulation was rather low. In countries with tightly regulated product markets, the accommodation from lower government bond yields had no significant effect across sectors or benefited more to less indebted sectors. Thus product market regulation acts to divert the benefits of easier funding conditions away from indebted sectors[120].

Our identification strategies are as follows. In the first part on countercyclical monetary policy and credit constraints we use the well-known Rajan-Zingales methodology and interact interest rate cyclicality and product market regulation with credit or liquidity constraints of the corresponding sectors in the US. In the second part we make use of the OECD forecasts of government bond yields and use difference between the realized and the forecasted yield to proxy for the unexpected change in the yield and thereby in funding conditions to the economy. While it would be wrong to argue that all such forecast errors are attributable to the ECB's announcement of OMT, we centre the analysis on this announcement and show that striking differences in the pattern of these errors appear when comparing the period preceding to the period following the announcement. In addition, we interact this unexpected change in long-term government bond yields following OMT with sectoral indebtedness measured prior to the unravelling of the European sovereign debt crisis.

This paper relates to the existing literature on macroeconomic volatility and growth. A benchmark paper in this literature is Ramey and Ramey (1995) who find a negative correlation in cross-country regressions between volatility and long-run growth. Subsequently, Aghion et al (2010) looked at the relationship between credit constraints, volatility, and the composition of investment between long-term growth-enhancing (R&D) investment and short term (capital) investment, and showed that more macroeconomic volatility is associated with a lower fraction of investment devoted to R&D and to lower productivity growth. More closely related to this paper is Aghion, Hemous and Kharroubi (2012), which showed that more countercyclical fiscal policies affect growth more significantly in sectors whose US counterparts are more credit constrained. Our paper contributes to this overall literature by introducing monetary policy and competition (or product market regulation) into the analysis[121].

The remaining part of the paper is organized as follows. Section 2 develops a simple model to analyse the interplay between monetary policy, competition, and growth. Section 3 looks at how long-term industry growth is affected by the interaction between the cyclicality of monetary policy interacted and product market competition. Section 4 looks at the effect on long-term industry growth on the unexpected drop in long-term government bond yields following OMT, and at how the magnitude of this effect is itself affected by product market competition. And Section 5 concludes.

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[120] In addition to these results, the empirical analysis also shows that high debt tends to be a drag on growth but that product market regulation tends to dampen this negative effect.

[121] See also Aghion and Kharroubi (2013) who look at the relationship between monetary policy and financial regulation. It shows that tighter financial regulation – in the form of higher bank capital ratios- may contribute to reducing the growth-enhancing effect of a more counter cyclical monetary policy.

2 Model

2.1 Basic setup

The model is a straightforward extension of that in Aghion et al (2013). The economy is populated by non-overlapping generations of two-period lived entrepreneurs. Entrepreneurs born at time t have utility function $U = \mathbb{E}[c_{t+2}]$, where c_{t+2} is their end-of-life consumption. They are protected by limited liability and A_t is their endowment at birth at date t. Their technology set exhibits constant returns to scale. Upon being born at date t, the new generation of entrepreneurs choose their investment scale $I_t > 0$.

At the interim date $t+1$ uncertainty is realized: it consists of both, of an aggregate shock which is either good (G) or bad (B), and of an idiosyncratic liquidity shock. The two events are independent and we denote by μ the probability of a good aggregate shock, and by α the probability of a firm experiencing a liquidity shock.

At date $t+1$, an interim cash flow $\pi_i(c)I_t$ accrues to the entrepreneur where $\pi_i(c) \in \{\pi_G(c), \pi_B(c)\}$ with $\pi_G(c) > \pi_B(c)$ and c is a parameter which measures the degree of product market competition and $\pi_i'(c) < 0$. We assume in what follows that $c \in \{\underline{c}, \overline{c}\}$ so that $c = \overline{c}$ (resp. $c = \underline{c}$) reflects high competition (resp. low competition) on the product market.

The interim cash flow is not pledgeable to outside investors. But other returns generated by the firm are pledgeable. We assume that in the absence of a liquidity shock, the other returns are obtained already at date $t+1$: namely, the entrepreneur generates the additional return $\rho_1 I_t$, of which ρI_t is pledgeable to investors[122]. If the firm experiences a liquidity shock, then the additional return is earned at date $t+2$ provided additional funds $J_{t+1} \leq I_t$ are reinjected into the project in the interim period. The entrepreneur then gets $\rho_1 J_{t+1}$ at date $t+2$, of which only ρJ_{t+1} is pledgeable to investors.

Entrepreneurs in the economy differ with respect to the probability α of a liquidity shock. Namely: $\alpha \in \{\underline{\alpha}, \overline{\alpha}\}$ with $\overline{\alpha} > \underline{\alpha}$. We interpret the probability α as a measure of liquidity-constraint.

The one period gross rate of interest at the investment date t is denoted by R, whereas R_s denotes the one period gross rate of interest at the reinvestment date $t+1$ when the aggregate shock is $s, s \in \{G; B\}$. We assume:

- Assumption 1: $\rho < min\{R, R_G, R_B\}$

[122] The model assumes that competition only affects short-term profits and not long-run profits. It can actually be argued that if long-run profits are those associated to innovation, they would be less sensitive to competition as innovation is precisely a way to escape it. By contrast, short-term profits are those derived from existing activities and products and thereby more subject to competitive pressures.

Assumption 1 ensures that entrepreneurs are constrained and must invest at a finite scale. The next assumption determines how easy/difficult reinvestment is, for entrepreneurs facing a liquidity shock.

- Assumption 2: $\pi_G(\overline{c}) > 1$ and $1 - \pi_B(\underline{c}) - \rho/R_B > 0 > 1 - \pi_B(\overline{c}) - \rho/R_B$.

Assumption 2 guarantees that, irrespective of the degree of product market competition c, cash flows in the good state are enough to cover liquidity needs and reinvest at full scale if a liquidity shock hits. However, in the bad state, cash flows alone are enough to cover liquidity needs only if competition is low, i.e. $c = \underline{c}$. If competition is high, i.e. $c = \overline{c}$, and the bad state realizes, then a firm facing a liquidity shock will have to use additional liquidity set aside at the investment date t if it wants to reinvest at full scale.

We assume that liquidity hoarding is costly: to purchase an asset that pays-off $x_0 I_t$ at date $t+1$, the entrepreneur needs to hoard the amount $q(1-\mu)\alpha x_0 I_t / R$ at date t, where $q > 1$. The difference $(q-1)$ reflects the cost of liquidity hoarding.

Entrepreneurs face the following trade-off: on the one hand, maximizing the amount invested in its project requires minimizing the amount of liquidity hoarded, which in turn may prevent the firm from reinvesting at large scale if it faces a liquidity shock and the economy experiences a bad aggregate shock; on the other hand, maximizing liquidity to mitigate maturity mismatch requires sacrificing initial investment scale.

2.2 Investment, liquidity hoarding and reinvestment in equilibrium

Let us first consider a firm's reinvestment decision at the interim period $t+1$. If it faces both a liquidity shock and a bad aggregate shock, a firm born at date t can use its short-term profits $\pi(c)I_t$, plus the amount of hoarded liquidity $x_0 I_t$ if any, plus the proceeds from new borrowing at date $t+1$ (the entrepreneur can borrow against the pledgeable final income ρJ_{t+1}), for reinvestment at date $t+1$. More formally, if $J_{t+1} \epsilon [0, I_t]$ denotes the firm's reinvestment at date $t+1$, we must have:

$$J_{t+1} \leq (x_0 + \pi_B(c))I_t + \frac{\rho}{R_B} J_{t+1} \quad (1)$$

or:

$$J_{t+1} \leq min\left\{\frac{x_0 + \pi_B(c)}{1 - \rho/R_B}, 1\right\} I_t \quad (2)$$

In particular, a lower interest rate in the bad state R_B facilitates refinancing because this increases the ability to issue claims at the reinvestment date and hence reduces the need to hoard liquidity at the investment date which in turn saves on the cost of liquidity given the positive liquidity premium $(q > 1)$.

Moving back to date t, we can determine the equilibrium hoarding and investment at that date. Starting with initial wealth A_t, the entrepreneur needs to raise $I_t - A_t$ at date t from outside investors to invest I_t in its project. In addition, the firm must anticipate the need for reinvestment if a liquidity shock hits in the bad aggregate state: to face such possibility, the entrepreneur will rely on both, liquidity hoarding to get the additional liquidities $x_0 I_t$ at date $t+1$ and additional future borrowing by issuing new claims $x_1 I_t$ to investors against the final pledgeable cash flow.

If the return ρ_1 to long-term projects is sufficiently large, then in equilibrium the entrepreneur chooses the maximum possible investment size I_t, which is the investment such that all these calls on investors will have to be exactly matched by the total present expected flow of pledgeable income generated by the firm. Hence the equilibrium investment size I_t will satisfy:

$$(I_t - A_t) + \alpha(1-\mu)\left[\frac{x_1 I_t}{R} + q\frac{x_0 I_t}{R}\right] = (1-\alpha)\frac{\rho}{R} I_t + \alpha\left[\mu\frac{\rho}{RR_G} I_t + (1-\mu)\frac{(\pi_B(c) + x_0 + x_1)\rho}{RR_B} I_t\right] \quad (3)$$

where x_0 and $x_1$are optimally chosen in dates t and $t+1$ respectively.

In fact to achieve the maximum investment size I_t the entrepreneur will borrow up to the constraint and choose the minimum amount of liquidity compatible with full reinvestment:

$x_1 = \rho/R_B$ and $x_0 = 1 - \pi_B(c) - \rho/R_B$

whenever the latter expression holding if is positive; otherwise liquidity hoarding can be avoided and $x_0 = 0$. Overall, if ρ_1 is sufficiently large, the equilibrium investment size I_t is given by:

$$\frac{I_t}{A_t} = \frac{R}{R - \left(1 - \alpha + \alpha\frac{\mu}{R_G}\right) + \alpha(1-\mu)qx} \quad (4)$$

where

$$x = \left[1 - \pi_B(1-c) - \frac{\rho}{R_B}\right]^+ .$$

2.3 Growth and countercyclical interest rates.

We assume that the growth rate of total factor productivity for a firm between period t and period $t+2$ is given by:

$$A_{t+2} = g.I_t.A_t \quad (5)$$

where g is a positive scalar. Then, using the above expression (4) for entrepreneurs' ex ante long-term investment I_t, growth in this economy g_{t+2} writes as:

$$g_{t+2} = \ln A_{t+2} - \ln A_t = \ln g + \ln\frac{R}{R - \left(1 - \alpha + \alpha\frac{\mu}{R_G}\right)\rho + \alpha(1-\mu)qx}, \quad (6)$$

where

$$x = \left[1 - \pi_B(1-c) - \frac{\rho}{R_B}\right]^{+}.$$

To derive the comparative statics of growth with respect to the cyclicality of interest rates, we consider the effect of changing the spread between the interest rates $\{R_B; R_G\}$ keeping the average one period interest rate at the interim date, $(1-\mu)R_B + \mu R_G = R_m$ constant. A higher R_G will then correspond to more countercyclical interest rates. We can rewrite the above equation as:

$$\ln\frac{A_{t+2}}{A_t} = \ln gR - \ln\left[R - \left(1 - \alpha + \alpha\frac{\mu}{R_G}\right)\rho + \alpha(1-\mu)q\left[1 - \pi_B(c) - \frac{(1-\mu)\rho}{R-\mu R_G}\right]^{+}\right] \quad (7)$$

As is clear holding the average interest rate R constant, growth depends on three key parameters: First the degree of interest rate countercyclicality captured here by the level of the interest rate R_G. Second, the probability for firms to face the liquidity shock and third the degree of product market competition c. Let us detail below the different comparative statics.

2.4 Competition, countercyclical interest rates and growth

Given Assumption 2 which states that firms need to hoard liquidity only when competition is high, we immediately get that growth when competition is low writes

$$ln\frac{A_{t+2}}{A_t}(\underline{c}) = ln\ gR - ln\left[R - \left(1 - \alpha + \alpha\frac{\mu}{R_G}\right)\rho\right]$$

while the expression for growth turns out to be

$$ln\frac{A_{t+2}}{A_t}(\overline{c}) = ln\ gR - ln\left[R - \left(1 - \alpha + \alpha\frac{\mu}{R_G}\right)\rho + \alpha(1-\mu)q\left[1 - \pi_B(\bar{c}) - \frac{(1-\mu)\rho}{R-\mu R_G}\right]\right]$$

when competition is high.[123]

It follows that an increase in the countercyclicality of monetary policy, i.e. a higher interest rate R_G, is more likely to enhance growth when competition on the product market is high (i.e. when $c = \overline{c}$) than when it is low:

$$\left.\frac{\partial g_{t+2}}{\partial R_G}\right|_{c=\overline{c}} > \left.\frac{\partial g_{t+2}}{\partial R_G}\right|_{c=\underline{c}}$$

Moreover a countercyclical monetary policy, i.e. a higher interest rate R_G, is more likely to benefit to firms facing a larger probability α of the liquidity shock, when competition on the product market is high than when it is low:

[123] Note that this model, with its current framework, would predict that growth is higher with lower competition. A simple extension that would make the model more realistic from this point of view would be to introduce an escape competition effect as in Aghion et al (2005). For example by assuming that firms make a pre-innovation profit when they do not invest, and that this pre-innovation profit decreases more with competition than the post investment profit. Importantly, this would not affect the main predictions that (i) more countercyclical interest rates are more growth enhancing for firms that are more prone to liquidity shocks and (ii) that this property holds particularly when competition is high.

$$\left.\frac{\partial^2 g_{t+2}}{\partial R_G \partial \alpha}\right|_{c=\bar{c}} > \left.\frac{\partial^2 g_{t+2}}{\partial R_G \partial \alpha}\right|_{c=\underline{c}}$$

3 The complementarity between financial constraints, countercyclical interest rates and product market competition

In this section we use cross-country, cross-industry panel data across OECD and Euro Area countries to analyse the growth effect of countercyclical monetary policies and how the magnitude of that effect is itself affected by product market competition. More specifically, we test the prediction from our above theoretical analysis that a countercyclical monetary policy should be more growth-enhancing for liquidity dependent industries, particularly when product market competition is stronger.

We proceed in two steps. First, we rely on the well-known Rajan-Zingales approach: We estimate the joint effect of industry liquidity dependence and country-level interest rate cyclicality on growth at the industry level across a set of manufacturing sectors and countries. As is the rule in this approach, we impute differences in liquidity dependence across sectors to those observed over a set of similar sectors in the US. Finally we test whether the joint effect of sectoral liquidity dependence and country-level interest rate cyclicality on industry growth actually depends on the (inverse) degree of product market competition measured by the index for product market regulation.

Our second approach focuses on the experience of the Euro Area, looking at growth developments before and after the announcement of OMT. Specifically, we consider six Euro Area countries – which commonly faced the OMT shock – but had significantly different outcomes, especially in terms of changes in government bond yields. We exploit these cross-country differences along with cross-sectoral differences in financial and liquidity dependence to infer whether sectors with fragile balance sheets did actually benefit more from the fall in government bond yields for the country they operate in. In addition to this, we use differences in product market regulation among these six Euro Area countries to test how competition changes the growth effects of the accommodation episode that followed the announcement of OMT.

3.1 The Rajan-Zingales estimation strategy

We take as a dependent variable the growth rate at the sector level for each industry-country pair of the sample under study. Given data availability, we can look at growth in real value added and growth in real labour productivity (real value added per worker). For obvious reasons, we will focus on the latter. On the right hand side, we introduce industry and country fixed effects. Industry fixed effects are dummy variables which control for any cross-industry difference in growth that is constant across countries. Similarly country fixed effects are dummy variables which control for any cross-country difference in growth that is constant across industries. Our main variable of interest is the interaction between: (i) an industry's level of financial constraint – denoted (fc); and (ii) a country's degree of monetary policy countercyclicality-denoted (ccy). In addition, we consider two other variables of interest: First the interaction between the latter interaction variable and (iii) the degree of product market regulation – denoted (reg) which we measure at the country level. Second, the interaction between industry financial constraints and the degree of product market regulation. Denoting g_{sc} the growth rate of industry s in country c, α_s and α_c industry and country fixed effects, and letting ε_{sc} denote an error term, our baseline regression is expressed as follows:

$${}_{sc} = \alpha_s + \alpha_c + \beta_1 (fc)_s \times (reg)_c + \beta_2 (fc)_s \times (ccy)_c + \beta_{21} (fc)_s \times (ccy)_c \times (reg)_c + \varepsilon_{sc} \quad (8)$$

The coefficients of interest are β_1, β_2 and β_{21}. According to the model derived above, we would expect that a more countercyclical real short-term interest rate has a stronger growth-enhancing effect on more financially constrained industries, i.e. $\beta_2 > 0$ and the more so when the level of product market regulation is lower, i.e. $\beta_{21} < 0$ (recall that (reg) is an inverse measure of competition). Last, we also expect that financially constrained sectors perform better when product market regulation is tighter, i.e. $\beta_1 > 0$ as the presence of monopoly rents can actually soften the impact of financial constraints.

3.2 The explanatory variables

3.2.1 Industry financial constraints

We consider two different variables for industry financial constraints $(fc)_s$, namely credit constraints and liquidity constraints. Following Rajan and Zingales (1998), we use US firm-level data to measure credit and liquidity constraints in sectors outside the United States. Specifically, we proxy industry credit constraint with asset tangibility for firms in the corresponding sector in the US. Asset tangibility is measured at the firm level as the ratio of the value of net property, plant, and equipment to total assets. We then consider the median ratio across firms in the corresponding industry in the US as the measure of industry-level credit constraint. This indicator measures the share of tangible capital in a firm's total assets and hence the fraction of a firm's assets that can be pledged as collateral to obtain funding. Asset tangibility is therefore an inverse measure of an industry's credit constraint. Now to proxy for industry liquidity constraints, we use the labour cost to sales ratio for firms in the corresponding sector in the US. An industry's liquidity constraint is therefore measured as the median ratio of labour costs to total sales across firms in the corresponding industry in the US. This captures the extent to which an industry needs short-term liquidity to meet its regular payments vis-à-vis its employees. It is a positive measure of industry liquidity constraint.[124]

Using US industry-level data to compute industry financial constraints, is valid as long as: (a) differences across industries are driven largely by differences in technology and therefore industries with higher levels of credit or liquidity constraints in one country are also industries with higher levels of credit or liquidity constraints in another country in our country sample; (b) technological differences persist across countries; and (c) countries are relatively similar in terms of the overall institutional environment faced by firms. Under those three assumptions, US-based industry-specific measures are likely to be valid measures for the corresponding industries in countries other than the United States. While these assumptions are unlikely to simultaneously hold in a large cross-section of countries which would include both developed and less developed countries, they are more likely to be satisfied when the focus turns, as is the case in this study, to advanced economies.[125] For example, if pharmaceuticals hold fewer tangible assets or have a lower labour cost to sales than textiles in the United States, there are good reasons to believe it is likely to be the case in other advanced economies as well.[126]

3.2.2 Country interest rate cyclicality

Now, turning to the estimation of real short-term interest rate cyclicality, $(ccy)_c$, in country c, we measure it by the sensitivity of the real short-term interest rate to the domestic output gap, controlling for the one-quarter-lagged real short-term interest rate. We therefore use country-level data to estimate the following country-by-country "auxiliary" equation:

$$rsir_{ct} = \eta_c + \theta_c . rsir_{ct-1} + (ccy)_c . y\_gap_{ct} + u_{ct} \quad (9)$$

where $rsir_{ct}$ is the real short-term interest rate in country c at time t – defined as the difference between the three months policy interest rate and the 3-months annualized inflation rate; $rsir_{ct-1}$ is the one quarter lagged real short-term interest rate in country c at time t; y_gap_{ct} measures the output gap in country c at time t – defined as the percentage difference between actual and trend GDP.[127] It therefore represents the country's current position in the cycle; η_c and θ_c are constants; and u_{ct} is an error term. The regression coefficient $(ccy)_c$ is a positive measure of interest rate countercyclicality. A positive (negative) regression coefficient $(ccy)_c$

[124] Liquidity constraints can also be proxied using a cash conversion cycle variable which measures the time elapsed between the moment a firm pays for its inputs and the moment it is paid for its output. Results available upon request are very similar to those obtained using the labour cost to sales ratio as a proxy for liquidity constraint.

[125] The list of countries in the estimation sample is available in Figure 1.

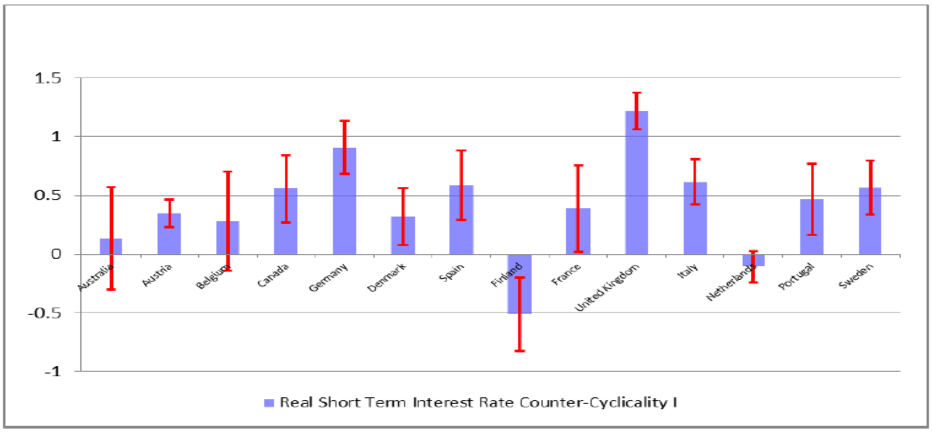
[126] Moreover, to the extent that the United States is more financially developed than other countries worldwide, US-based measures are likely to provide the least noisy measures of industry-level credit or liquidity constraints.

[127] Trend GDP is estimated applying an HP filter to the log of real GDP. Estimations show that results do not depend on the use of a specific filtering technique.

reflects a countercyclical (pro-cyclical) real short-term interest rate as it tends to increase (decrease) when the economy improves.

Figure 1

Monetary Policy Countercyclicality



Note: Each bar represents the estimated coefficient *ccy* in the country-by-country auxiliary regression detailed above. The red lines represent the confidence bands at 10% around the estimated coefficient.

3.2.3 Competition

We use as an (inverse) measure of competition the intensity of barriers to trade and investment (BTI). This is a country-wide indicator that measures the difficulty with which existing corporations can trade and invest.

3.3 Data sources

Our data sample focuses on 15 industrial OECD countries. The sample does not include the United States, as doing so would be a source of reverse causality problems. Our data come from various sources. Industry-level real value added and labour productivity data are drawn from the European Union (EU) KLEMS data set and are restricted to manufacturing industries. The primary source of data for measuring industry-specific characteristics is Compustat, which gathers balance sheets and income statements for US listed firms. We draw on Rajan and Zingales (1998), Braun (2003), Braun and Larrain (2005) and Raddatz (2006) to compute the industry-level indicators for borrowing and liquidity constraints. Finally, macroeconomic variables used to compute stabilization policy cyclicality are drawn from the OECD Economic Outlook data set. We use quarterly data for monetary policy variables over the period 1999-2005, during which monetary policy was essentially conducted through short-term interest rates to make sure that our auxiliary regression does capture the bulk of monetary policy decisions. Finally, the BTI data comes from the OECD and is measured for 1998.

3.4 Results

3.4.1 Countercyclical monetary policy and growth

We now turn to investigate the effect of monetary policy countercyclicality. To this end, we estimate our main regression equation (8) using as an industry measure of financial constraints either industry asset tangibility or industry labour costs to sales, the former being an inverse measure of financial constraints.

We first estimate equation (8) assuming $\beta_1 = \beta_{21} = 0$. We therefore start by shutting down any role for competition. The empirical results in Table 1 show that growth in industry real value added per worker is significantly and negatively correlated with the interaction of industry labour costs to sales and monetary policy countercyclicality (column (1)). A larger sensitivity to the output gap of the real short term interest rate tends to raise industry real valued added per worker growth disproportionately for industries with higher labour cost to sales. A similar but opposite type of results holds for the interaction between monetary policy cyclicality and industry asset tangibility: column (1) in Table 2 shows that a larger sensitivity of the real short term interest rate to the output gap raises industry real valued added per worker growth disproportionately less for industries with higher asset tangibility. These results are consistent with the view that a countercyclical monetary policy raises growth disproportionately in sectors that are more financially constrained or that face larger difficulties to raise capital, by easing the process of refinancing.[128]

3.4.2 Introducing competition

We now extend the previous regressions to allow the measure of barriers to trade and investment to affect industry growth, i.e. $\beta_1 \neq 0$ and $\beta_{21} \neq 0$. These estimations yield two results. First, barriers to trade and investment are less harmful for financially constrained sectors: Columns (2)-(4) in Table 1 show that the interaction of industry labour costs to sales and barriers to trade and investment relates positively to industry growth. Similarly, columns (2)-(4) in Table 2 show that the interaction of industry asset tangibility and barriers to trade and investment relates negatively to industry growth. This is evidence that monopoly rents help financially constrained firms go through downturns. However, column (4) also shows (in Table 1 and in Table 2) that barriers to trade and investment significantly reduce the benefits of monetary policy countercyclicality: Only when such barriers to trade and investment are below the sample median does the interaction between interest rate countercyclicality and financial constraints correlate positively with industry growth. When barriers to trade and investment are above the sample median, then interest rate countercyclicality has no effect. This means that monopoly rents tend to reduce

[128] It is worth noting that the correlation across sectors between asset tangibility and labour costs to sales is around −0.6. These are therefore two distinct channels through which interest rate countercyclicality affects industry growth.

monetary policy "effectiveness" insofar as this suggests that financially constrained firms have less incentives to raise credit and innovate in downturns.

Table 1

Growth, countercyclical monetary policy and barriers to trade and investment

		(1)	(2)	(3)	(4)
Dependent variable: Labour productivity Growth					
	Dummy variable				
log of initial hourly labour productivity		**-3.492***** (1.059)	**-3.580***** (1.071)	**-3.642***** (1.091)	**-3.646***** (1.092)
Interaction (Labor Costs to Sales and Interest rate counter-cyclicality)		**19.51**** (8.924)		**15.01***** (4.708)	
Interaction (Labor Costs to Sales and Barriers to Trade and Investment)			**24.08**** (9.475)	**21.06***** (6.069)	**25.82***** (6.906)
Interaction (Labor Costs to Sales and Interest rate counter-cyclicality)	*Below median BTI*				**18.02**** (6.962)
Interaction (Labor Costs to Sales and Interest rate counter-cyclicality)	*Above median BTI*				**6.697** (4.317)
Observations		552	552	552	552
R-squared		0.361	0.357	0.368	0.369

Note: Each column presents the estimation results from a cross-country cross-sector panel regression where the dependent variable is labour productivity growth measured over 1999-2005 and the explanatory variable are indicated in the first column of the table. Initial hourly labour productivity is measured in 1995. Labour cost to sales is the median ratio of labour costs to sales for firms in the corresponding US sector and interest rate countercyclicality is the coefficient *ccy* estimated in the auxiliary regression. The dummy variable "*Below median BTI*" ("*Above median BTI*") is equal to one for countries whose barriers to trade and investment index is below (above) the sample median and zero otherwise. Interaction variables are computed as the product of variables in parenthesis. All estimations include the full set of country and sector fixed effects. Standard errors are clustered at the sector level. ***/**/* indicate statistical significance at the 1/5/10% levels.

Table 2

Growth, countercyclical monetary policy and barriers to trade and investment

		(1)	(2)	(3)	(4)
Dependent variable: Labour productivity Growth					
	Dummy variable				
log of initial hourly labour productivity		**-3.461***** (1.116)	**-3.438***** (1.093)	**-3.539**** (1.178)	**-3.522**** (1.186)
Interaction (Asset Tangibility and Interest rate counter-cyclicality)		**-14.89***** (3.772)		**-10.08**** (3.473)	
Interaction (Asset Tangibility and Barriers to Trade and Investment)			**-12.01** (9.343)	**-9.149*** (4.344)	**-13.72**** (5.778)
Interaction (Asset Tangibility and Interest rate counter-cyclicality)	*Below median BTI*				**-13.19***** (3.237)
Interaction (Asset Tangibility and Interest rate counter-cyclicality)	*Above median BTI*				**-1.33** (7.865)
Observations		552	552	552	552
R-squared		0.359	0.354	0.365	0.365

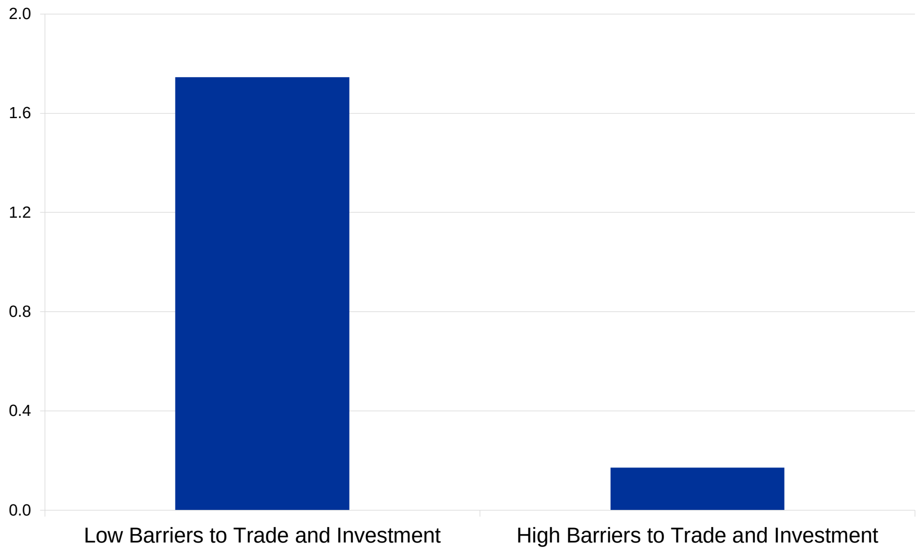
Note: Each column presents the estimation results from a cross-country cross-sector panel regression where the dependent variable is labour productivity growth measured over 1999-2005 and the explanatory variable are indicated in the first column of the table. Initial hourly labour productivity is measured in 1995. Asset tangibility is the median ratio of net property, plant and equipment to total assets for firms in the corresponding US sector and interest rate countercyclicality is the coefficient ccy estimated in the auxiliary regression. The dummy variable "*Below median BTI*" ("*Above median BTI*") is equal to one for countries whose barriers to trade and investment index is below (above) the sample median and zero otherwise. Interaction variables are computed as the product of variables in parenthesis. All estimations include the full set of country and sector fixed effects. Standard errors are clustered at the sector level. ***/**/* indicate statistical significance at the 1/5/10% levels.

Figure 2 shows the magnitude of the difference-in-difference effect when considering the labour cost to sales ratio as a measure of financial constraints. It shows that a sector with high labour cost to sales located in a country with high interest rate countercyclicality grows on average 1.6 percentage points more quickly than a sector with low labour cost to sales located in a country with low interest rate countercyclicality grows, this growth difference holding when barriers to trade and investment are low. By contrast when barriers to trade and investment are large, this growth difference is negligible.

Figure 2

The effect of countercyclical monetary policy on growth

(difference-in-difference effect; percentage points)



Note: Each bar measures the change in growth stemming from a joint change from the first to the third quartile in the industry distribution of labour cost to sales and from the first to the third quartile in country distribution in the estimated coefficient interest rate cyclicality ccy. The left bar assumes that the dummy "*Below median BTI*" is equal to one while the right bar assumes that the dummy "*Above median BTI*" is equal to one.

Overall, this suggests that active monetary policy tends to be more effective when product markets are less regulated, i.e. policy accommodation and structural reforms complement each other in generating more growth.

4 Monetary policy and structural reforms: the case of Outright Monetary Transactions

The previous approach we used to investigate the interaction between monetary policy cyclicality, financial constraints and competition was based on data observations for the 1999-2005 period. Yet this sample period lies within what is known as the great moderation period, over which business cycle volatility in advanced economies was rather low. In this context, it is arguable that the cyclical pattern of monetary policy, to the extent it matters in general, is likely to make less of a difference when business cycle volatility is contained. To push the argument to the limit, when business cycle volatility is zero, then the cyclical pattern on monetary policy just becomes irrelevant (and meaningless). Therefore, to strengthen our case for a complementarity between monetary policy and competition, we turn to investigating a more "turbulent" period, i.e. the European sovereign debt crisis and how the ECB policy response in the form of Outright Monetary Transactions (OMT) affected Euro Area countries.

4.1 The economic context

The European sovereign debt crisis started by the end of 2009 as several governments of Euro Area countries (most notably Greece, Portugal, Ireland, Spain and Cyprus) were facing increasing difficulties to repay or refinance their sovereign debt or to bail out over-indebted banks. These growing financial difficulties triggered calls for assistance from third parties like other Euro Area countries, the ECB and the IMF, especially as redenomination risks mounted, i.e. the risk that these countries may have no other options than to default and exit from the Eurozone.

Several initiatives were undertaken to confront this debt crisis, among which the implementation of the European Financial Stability Facility (EFSF) and European Stability Mechanism (ESM), which acted as vehicles for financial support in exchange of measures designed to address the longer-term issues of government and banking sectors' financing needs. The ECB contribution to addressing the European sovereign debt crisis took several forms, including lowering policy rates and providing cheap loans of more than one trillion euro. Yet, the most decisive policy action was on 6 September 2012, by which the ECB announced free unlimited support for all Euro Area countries involved in a sovereign state bailout/precautionary programme from EFSF/ESM, through some yield lowering Outright Monetary Transactions (OMT). Arguing that divergence in short-term bond yields is an obstacle to ensuring that monetary policy is transmitted equally to all the Eurozone's member economies, the ECB portrayed (purchases under) the OMT programme as "an effective back stop to remove tail risks from the euro area" and " safeguard an appropriate monetary policy transmission and the singleness of the monetary policy".[129]

Several studies have confirmed that following the announcement of OMT, a number of yields on Euro Area government bonds shrank considerably. For example, Altavilla et al. (2014) estimate that the Italian and Spanish 2-year government bond yields decreased by about 200 bps after the OMT announcement, yet leaving bond yields of the same maturity in Germany and France unchanged. De Grauwe and Ji (2014) suggest that the shift in market sentiment triggered by the OMT announcement accounts for most of the decline in bond yields that was observed at that time, rejecting the view that improved fundamentals have played a significant role. These results are actually consistent with the fact that OMT was never practically used.

4.2 The empirical methodology

Our goal consists in finding out what real effects the drop in government bond yields of Euro Area countries that followed the OMT programme had. To do so, we use OECD Economic Outlook quarterly projections for short and long term interest rates

[129] Executive Board member, Benoît Cœuré described OMT as follows: "OMTs are an insurance device against redenomination risk, in the sense of reducing the probability attached to worst-case scenarios. As for any insurance mechanism, OMTs face a trade-off between insurance and incentives, but their specific design was effective in aligning ex-ante incentives with ex-post efficiency."

to infer the surprise component in the evolution of these interest rates.[130] More specifically we denote r^L_{ctq} the yield on the 10-year government bond in country c in quarter q of year t and

$$E[r^L_{ctq}|I_{t-1}]$$

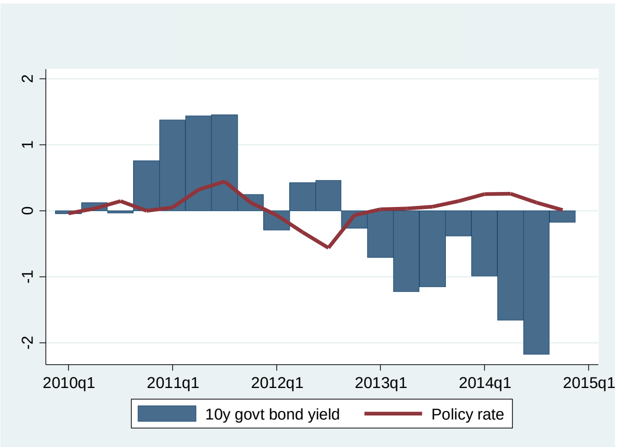
the projected yield on the 10-year government bond in country c in quarter q of year t, conditional on all information available by the end of year $t-1$.[131] We then compute the forecast error on this yield as

$$FE_{ctq} = r^L_{ctq} - E[r^L_{ctq}|I_{t-1}]$$

Here a positive forecast error reflects a higher than expected rate or yield, implying that funding conditions have unexpectedly tightened. On the contrary, negative forecast errors reflect easier than expected funding conditions. Computing these forecast errors for the four most significant Euro Area countries (France, Germany, Italy and Spain) shows a number of striking patterns. First there is a sharp drop in the forecast errors on 10 year government bond yields in Spain and Italy after 2012q3. While yields were significantly larger than expected over 2011, when the sovereign debt crisis was at its height, they ended up being significantly lower than expected over 2013 and 2014.

Figure 3a

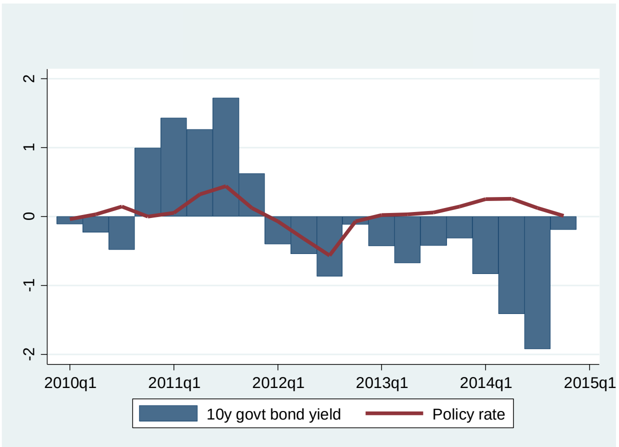
1-4 quarters ahead forecast errors (Spain)



Source: OECD Economic Outlook vintages and author's calculations.

Figure 3b

1-4 quarters ahead forecast errors (Italy)



Source: OECD Economic Outlook vintages and author's calculations.

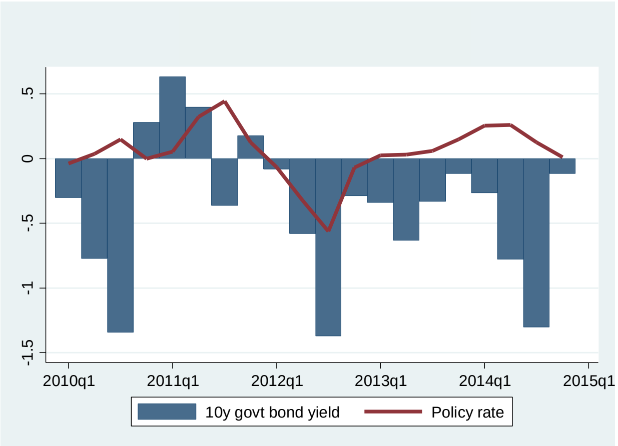
Second, interestingly, these changes do not extend to France and Germany, where the period 2011-2012 does not provide evidence of yields significantly higher than expected as these countries were on the contrary benefiting from their safe haven status.

130 Given that OMT was targeted to shorter maturity bonds (1-3 years), it would be more natural to look at those shorter maturity bonds than the 10-year bonds. In practise, however, OMT affected the whole yield curve of Euro Area countries. Hence looking at the 10-year bond is still acceptable.

131 Using this methodology implies that the forecast horizon ranges from one to four quarters at most.

Figure 4a

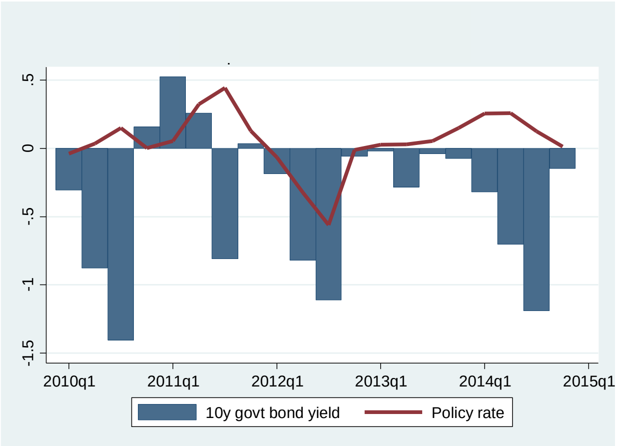
1-4 quarters ahead forecast errors (France)



Source: OECD Economic Outlook vintages and author's calculations.

Figure 4b

1-4 quarters ahead forecast errors (Germany)



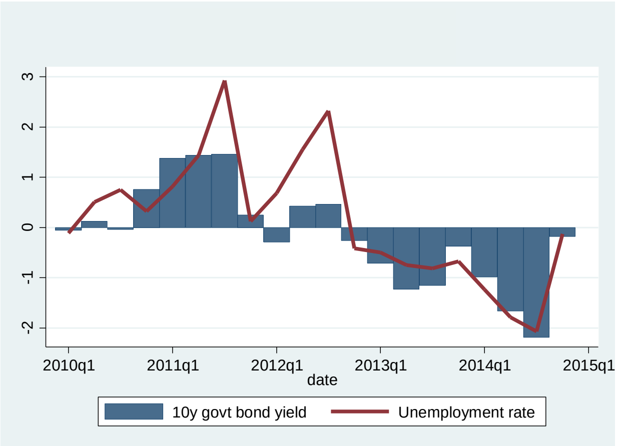
Source: OECD Economic Outlook vintages and author's calculations.

Of course, it is an open question to figure out how much of these changes relate to the specific OMT\ announcement and we do not intend to argue that OMT accounts for all these forecast errors. Yet, irrespective of the extent to which such forecast errors may be accounted for by OMT, they actually provide us with a good measure of the unexpected change in funding conditions in the relevant countries, and as such, are likely to have significant real effects.

4.3 Some hints at the real effects

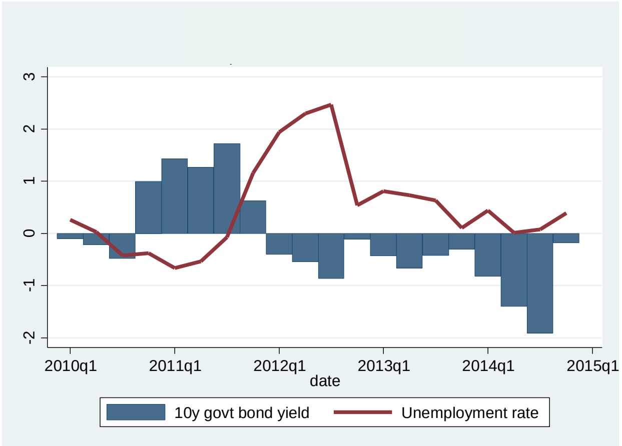
Before we move to the formal regression analysis, it is useful to look at how forecast errors in government bond yields correlate with forecast errors in other variables, namely unemployment, output growth or inflation. Focusing on Spain and Italy, which had the largest changes in forecast errors in government bond yields before/after OMT, we can see in Figures 5a and 5b that forecast errors in unemployment have trended down after the announcement of OMT in 2012q3 just as forecast errors in government bond yields did.

Figure 5a
1-4 quarters ahead forecast errors (Spain)



Source: OECD Economic Outlook vintages and author's calculations.

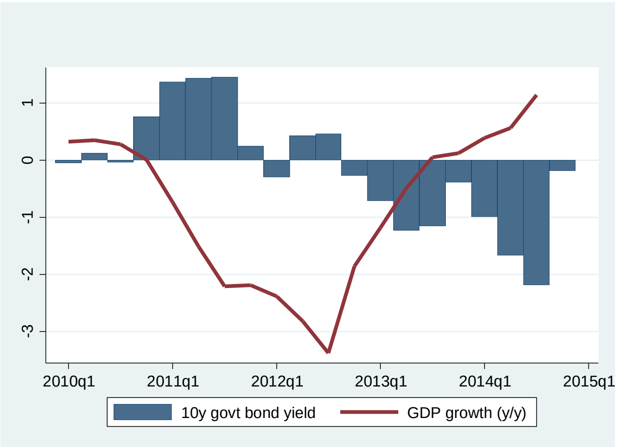
Figure 5b
1-4 quarters ahead forecast errors (Italy)



Source: OECD Economic Outlook vintages and author's calculations.

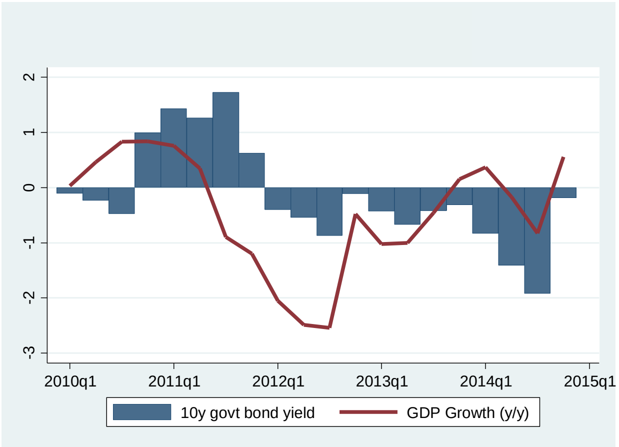
This suggests that unemployment and long-term interest rates are positively related with each other. A similar, but opposite result holds for GDP growth: Figures 6a and 6b show that in the case of Spain and Italy, reductions in forecast errors in government bonds yields have coincided with an increase in forecast errors in GDP growth. As is clear from the left hand panel 5a, the case of Spain is pretty striking as forecast errors following the OMT announcement have followed a very steep trend moving from −3 percentage points to almost zero within a few quarters after the OMT announcement. In Italy, forecast errors have moved from −2 percentage points to zero over the two-year horizon that followed the OMT announcement.

Figure 6a
1-4 quarters ahead forecast errors (Spain)



Source: OECD Economic Outlook vintages and author's calculations.

Figure 6b
1-4 quarters ahead forecast errors (Italy)



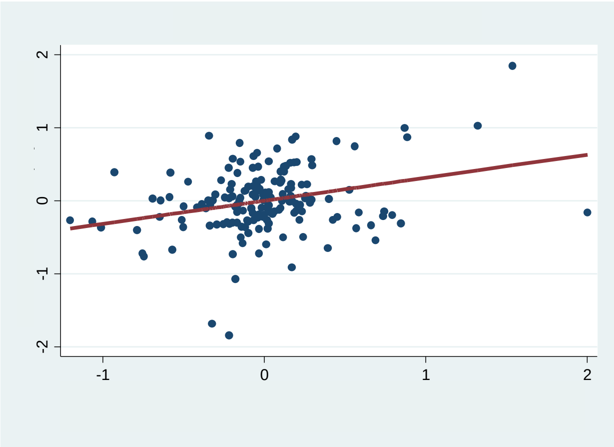
Source: OECD Economic Outlook vintages and author's calculations.

Looking beyond Spain and Italy, Figures 7a and 7b show two scatter plots based on quarterly data for a panel of countries (Austria, Belgium, Germany, Spain, Finland, France, United Kingdom, Italy, Netherlands, Sweden, United States) over the period running from 2011q1 to 2014q4. The left hand panel plots forecast errors in government bond yields against forecast errors in unemployment rates; the right hand panel plots forecast errors in government bond yields against forecast errors in GDP growth rates. Controlling for country and time dummies, the two panels confirm a positive and significant relationship between (deviations of) long term yields and unemployment (from forecasts) and a negative and significant relationship between (deviations of) long term yields and GDP growth (from forecasts).

Figure 7a

Bond yields and employment

(x-axis: forecast error in LT government bond yield; y-axis: forecast error in unemployment rate)

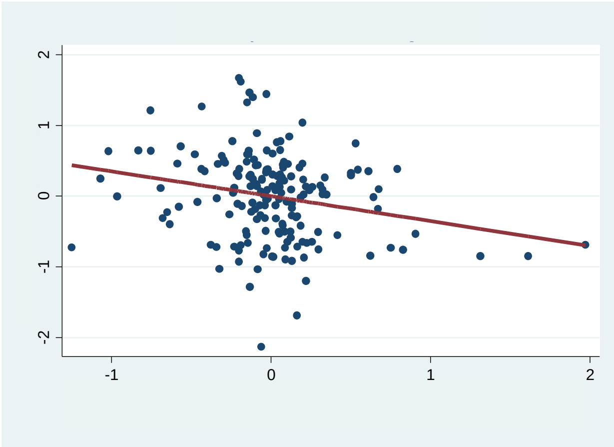


Note: estimated coef = 0.315, (robust) se = 0.130, t = 2.43.
Controls: 1-quarter lagged dependent variable, forecast error in policy rate, country and time dummies.

Figure 7b

Bond yields and GDP growth

(x-axis: forecast error in LT government bond yield; y-axis: forecast error in yearly GDP growth)



Note: estimated coef = −0.35201674, (robust) se = 0.10336794, t = −3.41.
Controls: 1-quarter lagged dependent variable, forecast error in policy rate, country and time dummies.

4.4 Empirical specification

To investigate the real effects of the unexpected drop in government bonds yields that followed the announcement of OMT, we consider a difference-in-difference approach focusing on the two periods of 2011-2012 and 2013-2014. For each of these periods, we compute the average forecast error on 10-year government bond yields and take the difference as a measure of the unexpected easing in funding conditions.

We then build an empirical specification linking this country-wide measure of lower funding costs to growth at the industry level. Specifically we take as a dependent variable the growth rate at the sector level for each industry-country pair of the sample under study over 2013-2014. Given data availability, we can look at growth in three different variables: real value added, real labour productivity (real value added per worker) and real capital productivity (real value added to real capital stock). On the right hand side, in addition to saturating the specification with industry and country fixed effects, we control for growth at the industry level over the period 2011-2012, so that all results can be interpreted as changes in growth relative to the 2011-2012 reference period.

Our main variable of interest is the interaction between: (i) an industry's balance sheet indicator – denoted $(debt)$; and (ii) the unexpected change in a country's funding conditions – denoted (omt). As explained above, the latter variable is computed as the difference between long term government bond yield average forecast error over 2013-2014, denoted FE_c^{13-14} and 2011-2012 denoted FE_c^{11-12}:

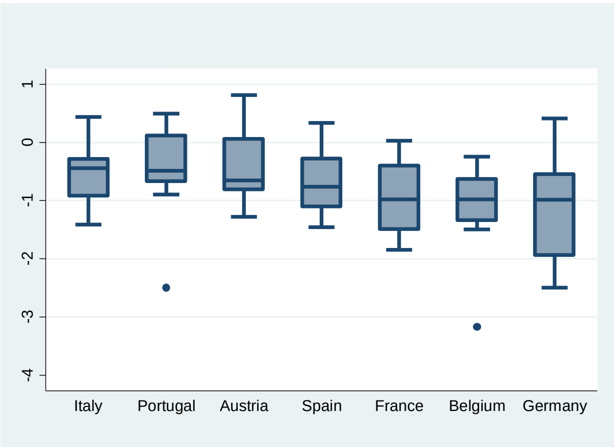
$$(omt)_c = FE_c^{13-14} - FE_c^{11-12}$$

Turning to industry balance sheet indicators, we consider two measure of indebtedness. A narrow indicator is the stock of bank debt as a ratio of total equity. A wider indicator is the stock bank debt and bonds as ratio of total equity. In addition we will also make use of liquidity indicators by looking at the ratio of current bank debt to equity or current bank debt and bonds to equity, current liabilities being those with a maturity less than one year. Importantly, industry balance sheet indicators are measured prior to the 2013-2014 period, namely either in 2010 or in 2012.

Figure 8a shows the distribution of the log of debt to equity ratio across sectors in 2010 for the countries included in the forthcoming estimations, countries being ranked by the median level. This shows that the median sector in Italy, Portugal and Austria was relatively more indebted in 2010 than in France, Belgium and Germany. Still, as is clear from the graph, Austria and Germany show pretty high levels of debt to equity ratio for a number of sectors. Figure 8b provides similar data but looking at the change in median log of debt to equity ratio across sectors between 2010 and 2012. It shows that Spain, Portugal and to a lesser extent Germany had significant corporate deleveraging with median debt to equity falling by more than 15% in both Spain and Portugal over two years. By contrast median debt to equity went up in France and Belgium between 2010 and 2012.

Figure 8a
Bank debt to equity

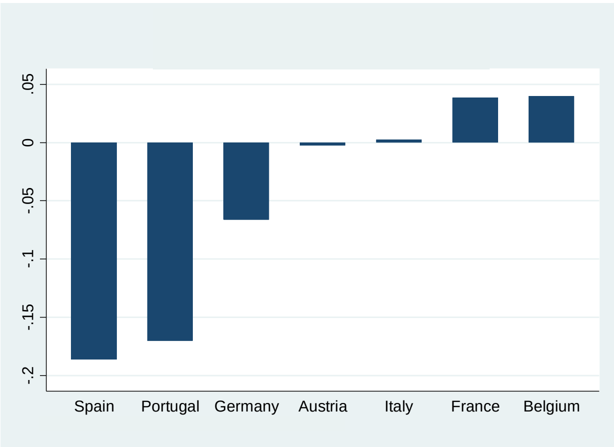
(2010)



Note: Data is in log-levels and covers 1-digit sectors.
Source: BACH and authors' calculations.

Figure 8b
Bank debt to equity

(change in median between 2010 and 2012)



Note: Data is in log-levels and covers 1-digit sectors.
Source: BACH and authors' calculations.

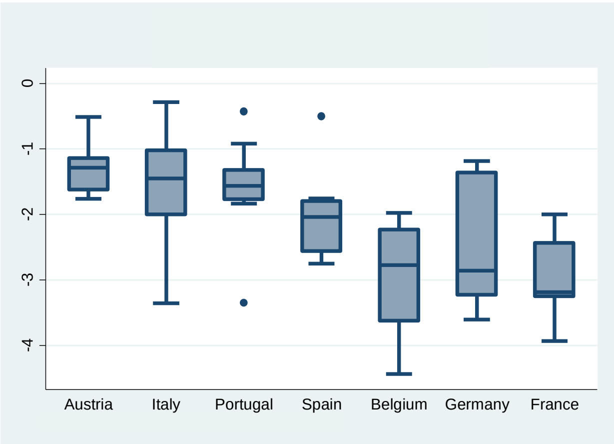
Turning to liquidity indicators, Figure 9a shows the distribution of the log of current debt to equity ratio across sectors in 2010 for a set of countries ranked by their median level. Countries with relatively high levels of short maturity debt include Austria, Italy and Portugal, while Belgium Germany and France rather feature low levels of short maturity debt.

Interestingly such ranking holds similarly for debt and current debt to equity ratio, suggesting that higher overall debt levels are achieved by larger reliance on short term debt. Yet the right-hand panel in Figure 9b shows that the evolution of current debt to equity over the European sovereign debt crisis (2010-2012) has been rather unrelated with initial short term debt levels in 2010. For instance, in both France and Austria, the median short term debt to equity decreased by a significant 10%. However France held relatively low levels of short term debt to equity in 2010 while Austria had relatively high levels of short term debt to equity in 2010. Conversely, Germany which had relatively low levels of short term debt to equity in 2010 faced a significant increase which amounted to almost 50% within two years.

Figure 9a

Current bank debt to equity

(2010)

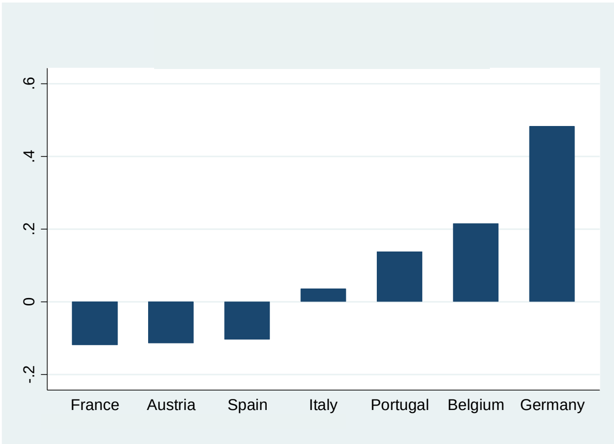


Note: Data is in log-levels and covers 1-digit sectors.
Source: BACH and authors' calculations.

Figure 9b

Current bank debt to equity

(change in median between 2010 and 2012)



Note: Data is in log-levels and covers 1-digit sectors.
Source: BACH and authors' calculations.

The empirical specification uses the growth rate of industry s in country c over the period 2013-2014 – denoted g_{sc}^{13-14} – as a dependent variable. On the right hand side, we include g_{sc}^{11-12} the growth rate of industry s in country c over the period 2011-2012, $(reg)_c$ the degree of product market regulation in country c, and the unexpected drop in long-term government bond yields $(omt)_c$. Denoting α_s and α_c industry and country fixed effects, and letting ε_{sc} denote an error term, our baseline regression is expressed as follows:

$$g_{sc}^{13-14} = \alpha_s + \alpha_c + \beta_0 . g_{sc}^{11-12} + \beta_1 . (debt)_{sc} + \beta_{11} . (debt)_{sc} \times (reg)_c + \beta_2 . (debt)_{sc} \times (omt)_c + \beta_{21} . (debt)_{sc} \times (omt)_c \times (reg)_c + \varepsilon_{sc} \qquad (10)$$

Here, the coefficient β_1 determines the unconditional effect of corporate indebtedness on growth while the coefficient β_{11} determines how product market regulation affects the relationship between corporate indebtedness and growth. Similarly, the coefficient β_2 determines the extent to which the drop in long term government bond yields benefits highly indebted sectors while the coefficient β_{21} determines how product market regulation affects this differential relationship between the change in funding conditions and sectoral growth. Intuitively and consistent with the model derived above, we would expect corporate indebtedness to be a drag on growth, i.e. $\beta_1 < 0$, while we would expect product market regulation to reduce the growth cost of corporate indebtedness, i.e. $\beta_{11} > 0$. In addition, a positive coefficient β_2 for instance would imply that highly indebted sectors benefit disproportionately more from an unexpected drop in funding costs while a negative coefficient β_{21} for instance would imply that product market regulation typically reduces the growth benefit of lower funding cost for the most indebted sectors.

4.5 Data Sources

Our data sample focuses on the big four Euro Area countries, namely France, Germany, Italy and Spain, to which we add Austria, Belgium and Portugal. Focusing on this limited set of countries is driven by data availability considerations. Our data come from various sources. Industry-level real value added, employment, capital stock and total factor productivity are drawn from the European Union (EU) KLEMS data set and cover the whole economy wherever data is available. Our source for sectoral balance sheet data is the BACH database. We draw from this dataset the sector-level balance sheet data for equity, bank debt, bonds, current bank debt and current bonds and financial payments. We carry out the estimations using the balance sheet data for either year 2010 or 2012 so that in both cases, the announcement of OMT would not contaminate these measures.[132] [133] The product market regulation data comes from the OECD and is measured for the year 2013. Finally, forecast errors in government bond yields are computed using quarterly data from the different vintages of the OECD Economic outlook database.[134]

4.6 Results

Tables 3.a and 3.b provide the estimation results for specification (10) under different parameter restrictions for each of the three different growth dependent variables referred to above (value added, labour productivity and capital productivity) using the ratio of bank debt to equity as a measure of sectoral indebtedness. Table 3a uses sectoral indebtedness measured in 2012, Table 3b uses sectoral indebtedness measured in 2010. Tables 4a and 4b provide a similar set of regressions, but using the wider measure of sectoral indebtedness, the ratio of bank debt and bonds to total

[132] In addition, the data for 2010 is not affected by the sovereign debt crisis.

[133] Using the actual balance sheet data instead of those pertaining to the corresponding US sector has two advantages. First, we can exploit the cross-country heterogeneity as the same sector features pretty diverse balance sheets when looking at different sectors. Second, the European sovereign debt crisis hit some countries more severely than others. This has prompted very diverse change in sectoral indebtedness across countries. These two features represent two sources of heterogeneity that can usefully be exploited in our context.

[134] The OECD publishes twice a year (June and December) forecasts over a two year horizon for a number of macroeconomic variables. We consider for each year $t + 1$ forecasts of the December issue of year t so that the forecast horizon never exceeds four quarters.

equity. As was the case previously, Table 4a uses the 2012 measure while Table 4b uses the 2010 measure.

In a nutshell, the empirical results suggest that the interaction between the unexpected reduction in government bond yields following OMT and corporate indebtedness, irrespective of the specific debt measure considered, seem to have a significant effect on industry growth, but only to the extent that cross-country differences in product market competition are taken into account. More precisely, looking at the second and third row of Tables 3a, 3b, 4a and 4b, the estimation results show that sectoral indebtedness has a weak negative effect on growth (columns (1), (5) and (9) in Tables 3a, 3b, 4a and 4b). However this weak negative effect hides a positive effect of product market regulation, which acts to dampen the negative effect of indebtedness on growth (columns (4), (8) and (12) in Tables 3a, 3b, 4a and 4b). Put differently, a large bank debt (and bond) to equity ratio acts as a drag on growth but only insofar as product markets are relatively unregulated. Product market regulation therefore acts to reduce the burden of high indebtedness on growth. Interestingly, this result holds mainly when the regression makes use of the 2012 measure of sectoral indebtedness. Estimates based on the 2010 measure are usually qualitatively similar but tend to be much less statistically significant. After all, this is sensible: indebtedness measured in 2010 is unlikely to affect growth over 2013-2014, especially when in between, a sovereign debt crisis has hit the economy and significantly changed corporate indebtedness.

Table 3a

Growth, financial conditions and product market regulation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dependent variable	Value Added Growth				Labor Productivity Growth				Capital Productivity Growth			
Lagged dependent variable	**0.247****	**0.242****	**0.240****	**0.244****	**0.155**	**0.151**	**0.152**	**0.160**	**0.361****	**0.356****	**0.309***	**0.302***
	(0.102)	*(0.098)*	*(0.095)*	*(0.094)*	*(0.104)*	*(0.102)*	*(0.107)*	*(0.109)*	*(0.169)*	*(0.169)*	*(0.161)*	*(0.158)*
Sectoral indebtedness	**-0.019****	**0.108**	**-0.0101**	**-0.196****	**-0.022***	**0.0741**	**-0.0141**	**-0.226****	**-0.024**	**0.034**	**-0.025**	**-0.284****
	(0.009)	*(0.111)*	*(0.008)*	*(0.096)*	*(0.012)*	*(0.117)*	*-0.01*	*(0.088)*	*(0.018)*	*(0.106)*	*(0.018)*	*(0.134)*
Interaction (**Sectoral indetedness** and **Product Market Regulation**)		**-0.094**		**0.141***		**-0.071**		**0.161****		**-0.044**		**0.196***
		(0.085)		*(0.073)*		*(0.091)*		*(0.068)*		*(0.078)*		*(0.101)*
Interaction (**Sectoral indetedness** and **Unexpected Drop in Yields**)	**0.008**	**0.007**	**0.276****	**0.411*****	**0.009**	**0.008**	**0.251***	**0.405****	**-0.023**	**-0.019**	**0.690*****	**1.064*****
	(0.005)	*(0.005)*	*(0.114)*	*(0.141)*	*(0.005)*	*(0.005)*	*(0.131)*	*(0.160)*	*(0.030)*	*(0.030)*	*(0.241)*	*(0.310)*
Interaction (**Sectoral indetedness**, **Unexpected Drop in Yields** and **Product Market Regulation**)			**-0.207****	**-0.311*****			**-0.188***	**-0.306****			**-0.497*****	**-0.768*****
			(0.085)	*(0.107)*			*(0.099)*	*(0.121)*			*(0.173)*	*(0.224)*
Sectors × Countries	35×7	35×7	35×7	35×7	35×7	35×7	35×7	35×7	34×5	34×5	34×5	34×5
Observations	220	220	220	220	220	220	220	220	144	144	144	144
R-squared	0.460	0.467	0.494	0.501	0.415	0.419	0.444	0.454	0.402	0.403	0.425	0.434

Note: Each column presents the estimation results from a cross-country cross-sector panel regression where the dependent variable measured over 2012-2014 is indicated in the second row and the explanatory variable are indicated in the first column of the table. The lagged dependent variable is measured over 2010-2012. Sectoral indebtedness is the log of bank debt to equity in 2012. The unexpected drop in yields is the difference between the average forecast error in 10-year government bond yields over 2013-2014 and the same average forecast over 2011-2012. Product market regulation is the average for 2013 of the state control index, the barriers to trade and investment index and the barriers to entrepreneurship index. Interaction variables are computed as the product of variables in parenthesis. All estimations include the full set of country and sector fixed effects. Standard errors are clustered at the sector level. ***/**/* indicate statistical significance at the 1/5/10% levels.

Table 3b

Growth, financial conditions and product market regulation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dependent variable	Value Added Growth				Labor Productivity Growth				Capital Productivity Growth			
Lagged dependent variable	**0.256****	**0.250****	**0.251****	**0.252****	**0.149**	**0.142**	**0.146**	**0.148**	**0.361****	**0.347****	**0.299****	**0.297***
	(0.104)	*(0.104)*	*(0.102)*	*(0.102)*	*(0.109)*	*(0.110)*	*(0.115)*	*(0.115)*	*(0.162)*	*(0.159)*	*(0.145)*	*(0.146)*
Sectoral indebtedness	**-0.014**	**0.171***	**-0.008**	**-0.061**	**-0.013**	**0.153**	**-0.007**	**-0.065**	**-0.014**	**0.207***	**-0.018**	**-0.090**
	(0.011)	*(0.090)*	*(0.010)*	*(0.092)*	*(0.013)*	*(0.093)*	*(0.012)*	*(0.090)*	*(0.023)*	*(0.122)*	*(0.023)*	*(0.161)*
Interaction (**Sectoral indetedness** and **Product Market Regulation**)		**-0.138***		**0.041**		**-0.124**		**0.044**		**-0.166***		**0.053**
		(0.071)		*(0.071)*		*(0.074)*		*(0.070)*		*(0.086)*		*(0.114)*
Interaction (**Sectoral indetedness** and **Unexpected Drop in Yields**)	**0.010***	**0.010****	**0.307*****	**0.350*****	**0.0101***	**0.010****	**0.283****	**0.329****	**-0.025**	**-0.013**	**0.868*****	**0.965*****
	(0.005)	*(0.005)*	*(0.095)*	*(0.124)*	*(0.005)*	*(0.005)*	*(0.112)*	*(0.148)*	*(0.029)*	*(0.029)*	*(0.201)*	*(0.313)*
Interaction (**Sectoral indetedness**, **Unexpected Drop in Yields** and **Product Market Regulation**)			**-0.229*****	**-0.262*****			**-0.211****	**-0.246****			**-0.626*****	**-0.696*****
			(0.071)	*(0.095)*			*(0.086)*	*(0.114)*			*(0.152)*	*(0.233)*
Sectors × Countries	35×7	35×7	35×7	35×7	35×7	35×7	35×7	35×7	34×5	34×5	34×5	34×5
Observations	220	220	220	220	220	220	220	220	144	144	144	144
R-squared	0.464	0.480	0.502	0.503	0.415	0.429	0.450	0.450	0.397	0.409	0.439	0.440

Note: Each column presents the estimation results from a cross-country cross-sector panel regression where the dependent variable measured over 2012-2014 is indicated in the second row and the explanatory variable are indicated in the first column of the table. The lagged dependent variable is measured over 2010-2012. Sectoral indebtedness is the log of bank debt to equity in 2010. The unexpected drop in yields is the difference between the average forecast error in 10-year government bond yields over 2013-2014 and the same average forecast over 2011-2012. Product market regulation is the average for 2013 of the state control index, the barriers to trade and investment index and the barriers to entrepreneurship index. Interaction variables are computed as the product of variables in parenthesis. All estimations include the full set of country and sector fixed effects. Standard errors are clustered at the sector level. ***/**/* indicate statistical significance at the 1/5/10% levels.

Turning now to the fourth and fifth rows of Tables 3a, 3b, 4a and 4b, we can see that on its own, a drop in funding costs – as captured by the change in forecast errors on government bond yields – does not benefit in a clear way to either more or less indebted sectors, this holding equally, irrespective of the specific definition or measurement timing of sectoral indebtedness (columns (1-2), (5-6) and (9-10) in Tables 3a, 3b, 4a and 4b). The interaction between the drop in the government bond yields and the sectoral indebtedness carries in some regressions a negative, although not significant, coefficient, suggesting that highly indebted sectors would benefit less from easier financial conditions, a result that seems at odds with any simple intuition. Yet as was the case previously, this inconclusive result hides conflicting patterns as highly indebted sectors do actually benefit more from easier funding conditions, but only in countries where the index for product market regulation is rather low (columns (3-4), (7-8) and (11-12) in Tables 3a, 3b, 4a and 4b). Otherwise, in countries with tightly regulated product markets, easier funding conditions either benefit equally to sectors with high and low debt, or benefit more to sectors with lower indebtedness. Last we can see that this= result is more robust than the result pertaining to the effect of sectoral indebtedness on growth as it holds across all the specifications. Looking now at turning points, the level of the product market regulation index beyond which the effect of the interaction term turns from positive to negative ranges between 1.31 and 1.34 for real value added growth (1.29 and 1.34 for labour productivity growth and 1.37 and 1.39 for capital productivity growth) and shows remarkable consistency across the different estimations, irrespective of the specific definition of sectoral indebtedness.

Table 4a

Growth, financial conditions and product market regulation

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Value Added Growth				Labor Productivity Growth				Capital Productivity Growth			
Lagged dependent variable	**0.242****	**0.238****	**0.232****	**0.236****	**0.187**	**0.185**	**0.183**	**0.190**	**0.356****	**0.352****	**0.325****	**0.321****
	(0.093)	*(0.089)*	*(0.087)*	*(0.087)*	*(0.119)*	*(0.116)*	*(0.119)*	*(0.122)*	*(0.168)*	*(0.168)*	*(0.157)*	*(0.152)*
Sectoral indebtedness	**-0.016***	**0.080**	**-0.008**	**-0.232****	**-0.021***	**0.03**	**-0.014**	**-0.272****	**-0.018**	**0.037**	**-0.025**	**-0.237**
	(0.008)	*(0.108)*	*(0.007)*	*(0.105)*	*(0.011)*	*(0.117)*	*(0.010)*	*(0.102)*	*(0.021)*	*(0.111)*	*(0.021)*	*(0.160)*
Interaction (**Sectoral indetedness** and **Product Market Regulation**)		**-0.071**		**0.171****		**-0.038**		**0.197****		**-0.042**		**0.158**
		(0.085)		*(0.082)*		*(0.092)*		*(0.081)*		*(0.090)*		*(0.125)*
Interaction (**Sectoral indetedness** and **Unexpected Drop in Yields**)	**-0.002**	**-0.002**	**0.242***	**0.405****	**-0.002**	**-0.002**	**0.204**	**0.392****	**-0.027**	**-0.024**	**0.519***	**0.831****
	(0.005)	*(0.005)*	*(0.119)*	*(0.164)*	*(0.004)*	*(0.004)*	*(0.139)*	*(0.186)*	*(0.032)*	*(0.034)*	*(0.264)*	*(0.346)*
Interaction (**Sectoral indetedness**, **Unexpected Drop in Yields** and **Product Market Regulation**)			**-0.188****	**-0.313****			**-0.158**	**-0.303****			**-0.380****	**-0.606****
			(0.090)	*(0.125)*			*(0.106)*	*(0.143)*			*(0.185)*	*(0.251)*
Sectors × Countries	35×7	35×7	35×7	35×7	35×7	35×7	35×7	35×7	34×5	34×5	34×5	34×5
Observations	220	220	220	220	220	220	220	220	144	144	144	144
R-squared	0.458	0.461	0.483	0.492	0.417	0.418	0.436	0.448	0.404	0.405	0.416	0.421

Note: Each column presents the estimation results from a cross-country cross-sector panel regression where the dependent variable measured over 2012-2014 is indicated in the second row and the explanatory variable are indicated in the first column of the table. The lagged dependent variable is measured over 2010-2012. Sectoral indebtedness is the log of bank debt and bonds to equity in 2012. The unexpected drop in yields is the difference between the average forecast error in 10-year government bond yields over 2013-2014 and the same average forecast over 2011-2012. Product market regulation is the average for 2013 of the state control index, the barriers to trade and investment index and the barriers to entrepreneurship index. Interaction variables are computed as the product of variables in parenthesis. All estimations include the full set of country and sector fixed effects. Standard errors are clustered at the sector level. ***/**/* indicate statistical significance at the 1/5/10% levels.

Table 4b

Growth, financial conditions and product market regulation

Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Value Added Growth				Labor Productivity Growth				Capital Productivity Growth			
Lagged dependent variable	**0.249****	**0.245****	**0.245****	**0.246****	**0.181**	**0.174**	**0.175**	**0.177**	**0.360****	**0.346****	**0.315****	**0.316****
	(0.095)	*(0.094)*	*(0.093)*	*(0.092)*	*(0.118)*	*(0.117)*	*(0.120)*	*(0.121)*	*(0.158)*	*(0.156)*	*(0.144)*	*(0.147)*
Sectoral indebtedness	**-0.009**	**0.155***	**-0.003**	**-0.069**	**-0.010**	**0.133**	**-0.004**	**-0.0735**	**-0.005**	**0.266****	**-0.0157**	**0.0122**
	(0.011)	*(0.088)*	*(0.010)*	*(0.092)*	*(0.013)*	*(0.090)*	*(0.012)*	*(0.102)*	*(0.026)*	*(0.116)*	*(0.025)*	*(0.181)*
Interaction (**Sectoral indetedness** and **Product Market Regulation**)		**-0.125***		**0.051**		**-0.108**		**0.053**		**-0.206****		**-0.021**
		(0.072)		*(0.073)*		*(0.074)*		*(0.081)*		*(0.086)*		*(0.131)*
Interaction (**Sectoral indetedness** and **Unexpected Drop in Yields**)	**0.001**	**0.003**	**0.284****	**0.338****	**0.002**	**0.003**	**0.255****	**0.311***	**-0.034**	**-0.019**	**0.879*****	**0.834****
	(0.006)	*(0.007)*	*(0.108)*	*(0.143)*	*(0.005)*	*(0.005)*	*(0.124)*	*(0.172)*	*(0.033)*	*(0.032)*	*(0.266)*	*(0.405)*
Interaction (**Sectoral indetedness**, **Unexpected Drop in Yields** and **Product Market Regulation**)			**-0.217****	**-0.258****			**-0.194****	**-0.237***			**-0.635*****	**-0.604****
			(0.080)	*(0.109)*			*(0.094)*	*(0.132)*			*(0.191)*	*(0.293)*
Sectors × Countries	35×7	35×7	35×7	35×7	35×7	35×7	35×7	35×7	34×5	34×5	34×5	34×5
Observations	220	220	220	220	220	220	220	220	144	144	144	144
R-squared	0.447	0.460	0.478	0.479	0.397	0.407	0.424	0.425	0.400	0.417	0.433	0.433

Note: Each column presents the estimation results from a cross-country cross-sector panel regression where the dependent variable measured over 2012-2014 is indicated in the second row and the explanatory variable are indicated in the first column of the table. The lagged dependent variable is measured over 2010-2012. Sectoral indebtedness is the log of bank debt and bonds to equity in 2010. The unexpected drop in yields is the difference between the average forecast error in 10-year government bond yields over 2013-2014 and the same average forecast over 2011-2012. Product market regulation is the average for 2013 of the state control index, the barriers to trade and investment index and the barriers to entrepreneurship index. Interaction variables are computed as the product of variables in parenthesis. All estimations include the full set of country and sector fixed effects. Standard errors are clustered at the sector level. ***/**/* indicate statistical significance at the 1/5/10% levels.

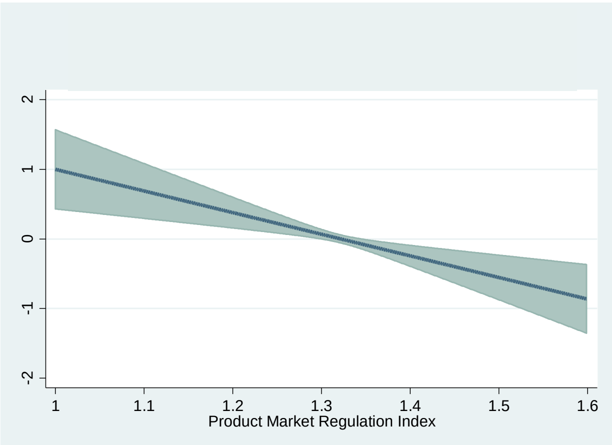
4.7 Quantifying the effect of product market regulation

Based on the empirical results described above, we can draw conclusions for each country of our sample as to what extent sectors located in each of these countries may have benefited from the unexpected drop in long term yields that followed OMT. To do so, we consider the value of the product market regulation index in each country and simulate the effect on sectoral real value added growth of a scenario in which long term government bonds yields unexpectedly drop by 100 basis points and the bank debt to equity ratio increases by 10%. Using estimates from regression (4) in Table 3a, two main conclusions can be drawn from this exercise. First there are two groups of countries: Austria, Germany, Italy and Portugal on the one hand and Belgium, France and Spain on the other hand. In the former group, where the product market regulation index is rather low, the combination of an increase in indebtedness and a reduction in government bond yields tends to raise growth. Interestingly, in these computations which assume a 100 basis point unexpected reduction in government bond yields, this effect tends to dominate from a quantitative standpoint the negative effect that would come from the drag on growth due to higher indebtedness. In the second group of countries, Belgium, France and Spain, where product market regulation is rather tight, the reduction in government bond yields that followed OMT has rather, if anything, benefited sectors with relatively low bank debt to equity. Tight product market regulation has therefore acted to redirect the benefits of lower funding costs to those sectors which had relatively stronger balance sheets, i.e. lower bank debt and hence arguably those sectors that were less in need for support.

Figure 10a

The growth effect of a 10% increase in debt to equity and a 100bps unexpected drop in LT yields

(percentage points)

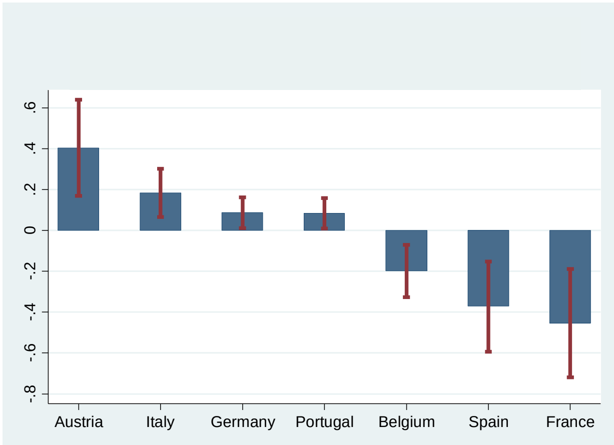


Note: The blue line represents the estimated effect on industry value added growth of a joint increase in the debt to equity ratio by 10% and a 100 basis points drop in long-term government bond yields, for different values of the product market index. The dark area around the blue line represents the confidence interval at the 10% level.

Figure 10b

The growth effect of a 10% increase in debt to equity and a 100bps unexpected drop in LT yields

(percentage points)



Note: The blue bars represents the estimated effect on industry value added growth of a joint increase in the debt to equity ratio by 10% and a 100 basis points drop in long-term government bond yields, for each country in the sample. The red lines represents the confidence interval at the 10% level.

4.8 Widening the investigation

Up to now, the empirical analysis has focused on the role of indebtedness in affecting growth at the sector-level directly and indirectly as a transmission channel for the effects of changes in funding conditions on growth. Yet, this ignores that firms funding conditions do not depend only on government bond yields but also on the health of the banking sector and the extent to which banks are willing or compelled to pass on to final borrowers the benefit of lower funding costs. This section is therefore devoted to check whether the state of the domestic banking sector may account for the effects of sectoral indebtedness and the drop in government bond yields on growth. To do so, we proceed in two steps. First, we augment the specification (10) to test whether the effect of indebtedness on growth depends on other factors than product market regulation:

$$g_{sc}^{13-14} = \alpha_s + \alpha_c + \beta_0 . g_{sc}^{11-12} + [\beta_1 + \beta_{11} . (reg)_c + \beta_{12} . (bank)_c] \times (debt)_{sc} + \beta_2 . (debt)_{sc} \times (omt)_c + \beta_{21} . (debt)_{sc} \times (omt)_c \times (reg)_c + \varepsilon_{sc} \quad (11)$$

We run regression (11) using five different indicators of the banking sector, denoted henceforth $(bank)_c$: concentration (share of the 3 largest banks in credit to the private sector), net interest margin, return on assets, return on equity and z-score. The first and second indicator provide a measure of low competitive is the domestic banking sector, while the third and the fourth indicator provide a measure of profitability. Last the fifth indicator provides a measure of riskiness. In addition to specification (11), we also test whether the state of the domestic banking sector can affect the transmission of the drop in government bond yields following OMT. Using the same set of banking indicators detailed above, we therefore estimate as a second step:

$$g_{sc}^{13-14} = \alpha_s + \alpha_c + \beta_0 . g_{sc}^{11-12} + \beta_1 (debt)_{sc} + \beta_{11} . (reg)_c (debt)_{sc} + [\beta_2 + \beta_{21} . (reg)_c + \beta_{22} (bank)_c] \times (debt)_{sc} \times (omt)_c + \varepsilon_{sc} \quad (12)$$

Table 5a provides estimation results for specification (11). It basically shows that out of the five banking indicators consider, only the net interest margin tends to affect significantly the relationship between indebtedness and growth. Specifically, when banks earn a higher interest margin, and the banking sector is arguably less competitive, then indebtedness tends to be less detrimental to growth. One explanation for this result is that in a less competitive banking sector, banks may be more willing to extend credit to highly indebted firms, as the large rents they benefit from can allow for temporary larger expositions to risky borrowers. Turning to Table 5b which provides estimation results for (12), we can see bank concentration tends to reduce the benefit for highly indebted sectors of lower government bond yields. This is consistent with the view that rents, no matter whether they are located, at the firm-level – through product market regulation – or at the bank-level – through bank concentration – tend to reduce the growth dividend of lower funding costs. As explained previously, firms benefiting rents are less sensitive to funding conditions as their profits provide them with some insulation against changing borrowing costs. But similarly, when the bank sector is strongly oligopolistic and concentration is high, then banks have little incentive to pass on to final borrowers the benefit of lower funding costs.

Alternatively, when government bond yields drop and banks benefit a capital gain on their government bond holdings, this windfall profit is less likely to be used to expand credit when the banking sector is more concentrated, more oligopolistic. The conclusion to be drawn from Tables 5a and 5b is hence that the state of the banking sector does matter for the extent to which indebtedness and falling government bond yields affect growth at the sector-level. Yet, this channel appears to work in addition, on top of the product market regulation channel that we have been focusing on.

Table 5a

Product market regulation vs. banking sector health

Dependent variable: Real Value Added Growth		(1)	(2)	(3)	(4)	(5)	(6)
Lagged dependent variable		**0.244****	**0.248****	**0.237****	**0.243****	**0.245****	**0.250****
		(0.0943)	*(0.0932)*	*(0.0933)*	*(0.0956)*	*(0.0955)*	*(0.0963)*
Interaction (**Sectoral indetedness** and **Unexpected Drop in Yields**)		**0.411*****	**0.490*****	**0.509*****	**0.409*****	**0.412*****	**0.481****
		(0.141)	*(0.161)*	*(0.156)*	*(0.146)*	*(0.143)*	*(0.191)*
Interaction (**Sectoral indetedness**, **Unexpected Drop in Yields** and **Product Market Regulation**)		**-0.311*****	**-0.369*****	**-0.388*****	**-0.310*****	**-0.311*****	**-0.365****
		(0.107)	*(0.121)*	*(0.119)*	*(0.109)*	*(0.107)*	*(0.145)*
Sectoral indebtedness		**-0.196****	**-0.188***	**-0.291****	**-0.192***	**-0.201****	**-0.287***
		(0.0958)	*(0.0939)*	*(0.108)*	*(0.0980)*	*(0.0972)*	*(0.159)*
Interaction (**Sectoral indetedness** and **...**)	**Product market regulation**	**0.141***	**0.180****	**0.187****	**0.141***	**0.140***	**0.200***
		(0.0726)	*(0.0801)*	*(0.0763)*	*(0.0729)*	*(0.0728)*	*(0.110)*
	Bank concentration		**-0.0786**				
			(0.0478)				
	Bank net interest margin			**2.987***			
				(1.726)			
	Bank return on assets				**-0.347**		
					(1.801)		
	Bank return on equity					**0.0397**	
						(0.162)	
	Bank z-score						**0.112**
							(0.136)
Sectors × Countries		35×7	35×7	35×7	35×7	35×7	35×7
Observations		220	220	220	220	220	220
R-squared		0.501	0.506	0.505	0.501	0.501	0.503

Note: Each column presents the estimation results from a cross-country cross-sector panel regression where the dependent variable is sectoral real value added growth over 2012-2014 and the explanatory variable are indicated in the first and second columns of the table. The lagged dependent variable is sectoral real value added growth over 2010-2012. Sectoral indebtedness is the log of bank debt to equity in 2012. The unexpected drop in yields is the difference between the average forecast error in 10-year government bond yields over 2013-2014 and the same average forecast over 2011-2012. Product market regulation is the average for 2013 of the state control index, the barriers to trade and investment index and the barriers to entrepreneurship index. Bank concentration is the asset share of the three largest banks in 2011. Bank net interest margin is the accounting value of bank's net interest revenue as a share of interest-bearing (total earning) assets in 2011. Bank return on assets is the average return on assets computed as the ratio of net income to total assets in 2011. Bank return on equity is the average return on equity computed as the ratio of net income to total equity in 2011. Bank z-score is computed as (ROA+ETA)/sd(ROA) where ROA is the ratio of net income to total assets in 2011, ETA is the ratio of total equity to total assets in 2011and sd(ROA) is the standard deviation of ROA in 2011. Interaction variables are computed as the product of variables in parenthesis. All estimations include the full set of country and sector fixed effects. Standard errors are clustered at the sector level. ***/**/* indicate statistical significance at the 1/5/10% levels.

Table 5b

Product market regulation vs. banking sector health

Dependent variable: Real Value Added Growth		(1)	(2)	(3)	(4)	(5)	(6)
Lagged dependent variable		**0.244****	**0.241****	**0.238****	**0.242****	**0.244****	**0.243****
		(0.0943)	*(0.0932)*	*(0.0963)*	*(0.0950)*	*(0.0949)*	*(0.0973)*
Sectoral indebtedness		**-0.196****	**-0.267****	**-0.352****	**-0.197****	**-0.196****	**-0.186**
		(0.0958)	*(0.107)*	*(0.170)*	*(0.0964)*	*(0.0961)*	*(0.130)*
Interaction (**Sectoral indetedness** and **Product Market Regulation**)		**0.141***	**0.193****	**0.262***	**0.143***	**0.142***	**0.132**
		(0.0726)	*(0.0804)*	*(0.132)*	*(0.0733)*	*(0.0732)*	*(0.100)*
Interaction (**Sectoral indetedness** and **Unexpected Drop in Yields**)		**0.411*****	**0.687*****	**0.643*****	**0.388****	**0.395****	**0.395***
		(0.141)	*(0.160)*	*(0.193)*	*(0.157)*	*(0.178)*	*(0.206)*
Interaction (**Sectoral indetedness, Unexpected Drop in Yields** and **...**)	**Product market regulation**	**-0.311*****	**-0.463*****	**-0.590****	**-0.284****	**-0.296****	**-0.294**
		(0.107)	*(0.108)*	*(0.229)*	*(0.126)*	*(0.143)*	*(0.180)*
	Bank concentration		**-0.0883***				
			(0.0442)				
	Bank net interest margin			**9.630**			
				(8.921)			
	Bank return on assets				**-1.526**		
					(2.022)		
	Bank return on equity					**-0.0527**	
						(0.235)	
	Bank z-score						**-0.0366**
							(0.253)
Sectors × Countries		35×7	35×7	35×7	35×7	35×7	35×7
Observations		220	220	220	220	220	220
R-squared		0.501	0.505	0.503	0.502	0.501	0.501

Note: Each column presents the estimation results from a cross-country cross-sector panel regression where the dependent variable is sectoral real value added growth over 2012-2014 and the explanatory variable are indicated in the first and second columns of the table. The lagged dependent variable is sectoral real value added growth over 2010-2012. Sectoral indebtedness is the log of bank debt to equity in 2012. The unexpected drop in yields is the difference between the average forecast error in 10-year government bond yields over 2013-2014 and the same average forecast over 2011-2012. Product market regulation is the average for 2013 of the state control index, the barriers to trade and investment index and the barriers to entrepreneurship index. Bank concentration is the asset share of the three largest banks in 2011. Bank net interest margin is the accounting value of bank's net interest revenue as a share of interest-bearing (total earning) assets in 2011. Bank return on assets is the average return on assets computed as the ratio of net income to total assets in 2011. Bank return on equity is the average return on equity computed as the ratio of net income to total equity in 2011. Bank z-score is computed as (ROA+ETA)/sd(ROA) where ROA is the ratio of net income to total assets in 2011, ETA is the ratio of total equity to total assets in 2011and sd(ROA) is the standard deviation of ROA in 2011. Interaction variables are computed as the product of variables in parenthesis. All estimations include the full set of country and sector fixed effects. Standard errors are clustered at the sector level. ***/**/* indicate statistical significance at the 1/5/10% levels.

4.9 Transmission channels

4.9.1 Current and non-current financial liabilities

In this section, we aim at expanding the analysis of transmission channels. To do so, we proceed in two steps. First we investigate the role of liquid liabilities. Specifically we separate current and non-current bank debt (and bonds), i.e. less than one year maturity and more than one year of maturity and build two sector-level indicators of financial liabilities: (i) the ratio of current bank debt (and bonds)\ to equity and (ii) the ratio of non-current bank debt (and bonds) to equity. We then extend the empirical specification (10) to allow those two indicators – denoted respectively $cdebt$ and $ncdebt$ – to affect growth separately and independently of each other. Specifically, we first test whether holding current and non-current financial liabilities have a different direct effect on growth at the sector level and how product market regulation affects this direct linkage if any.

$$g_{sc}^{13-14} = \alpha_s + \alpha_c + \beta_0 . g_{sc}^{11-12} + [\beta_1 + \beta_{11}.(reg)_c] \times (cdebt\ ncdebt)_{sc} + [\beta_2 + \beta_{21}.(reg)_c] \times (debt)_{sc} \times (omt)_c + \varepsilon_{sc} \quad (13)$$

For example it may well be that the drag from leverage on growth essentially comes from holding debt with a short maturity as such sectors are forced to forego profitable growth opportunities in order to ensure they will be able to service their debt, particularly those maturating quickly. Second, we test whether holding current and non-current financial liabilities affect the benefits a sector can derive from changes in funding conditions that followed OMT:

$$g_{sc}^{13-14} = \alpha_s + \alpha_c + \beta_0 . g_{sc}^{11-12} + [\beta_1 + \beta_{11} . (reg)_c] \times (debt)_{sc} + [\beta_2 + \beta_{21} . (reg)_c] \times (cdebt\ ncdebt)_{sc} \times (omt)_c + \varepsilon_{sc} \quad (14)$$

Here it is very much possible that sectors with significant amounts of short term debts may actually benefit more from lower funding costs, as these debts are maturing more quickly and hence provide more opportunities to benefit from the lower funding costs. The empirical evidence gathered in Table 6 (columns (2) and (5) provide estimation results of specification (12)) shows that neither the ratio of current debt (and bonds) to equity nor the ratio of non-current debt (and bonds) to equity seem to have, on their own, a direct effect on growth. This suggests that indebtedness, irrespective of its maturity, is what has a direct effect on growth, not any specific maturity segment of debt. The amount not the maturity of financial liabilities in relation to the level of equity is what matters for growth. Things are different when it comes to how the reduction in funding costs transmits to growth: Results from estimating specification (14) (columns (3) and (6) in Table 6) suggest that it is essentially sectors holding current liabilities which can expect a benefit from a reduction in government bond yields, but not those holding noncurrent liabilities for which there is no significant effect. And similarly, product market regulation tends to cut in a significant way, the benefit of reduced government bond yields essentially for sectors holding current liabilities, not for those holding noncurrent liabilities. This is consistent with the view that when liabilities have a shorter maturity, firms can more quickly reap the benefit of refinancing their debts on more favourable terms. Yet the results suggest that firms may have less incentives to turn this "financial windfall profit" into real decisions that would deliver higher growth when they are holding monopoly rents. Product market regulation therefore acts to decouple firms’ financial strength from firms’ real decisions.

Table 6

The role of liquid liabilities

Dependent variable: Sectoral Real Value Added Growth		(1)	(2)	(3)	(4)	(5)	(6)
measure of financial liabilities		bank debt			bank debt and bonds		
	maturity of financial liabilities						
Lagged dependent variable		**0.244**** *(0.094)*	**0.209**** *(0.086)*	**0.233**** *(0.090)*	**0.236**** *(0.087)*	**0.216**** *(0.089)*	**0.240**** *(0.104)*
Sectoral indebtedness	**all maturities**	**-0.196**** *(0.096)*		**-0.204**** *(0.097)*	**-0.240**** *(0.104)*		**-0.233**** *(0.107)*
Interaction (**Sectoral indebtedness** and **Product Market Regulation**)		**0.141*** *(0.073)*		**0.146*** *(0.073)*	**0.178**** *(0.081)*		**0.173**** *(0.083)*
Interaction (**Sectoral indebtedness** and **Unexpected Drop in Yields**)		**0.411***** *(0.141)*	**0.303**** *(0.119)*		**0.412**** *(0.164)*	**0.303**** *(0.145)*	
Interaction (**Sectoral indebtedness**, **Unexpected Drop in Yields** and **Product Market Regulation**)		**-0.311***** *(0.107)*	**-0.228**** *-0.091*		**-0.319**** *(0.126)*	**-0.233**** *(0.111)*	
Sectoral indebtedness	**less than one year maturity**		**-0.024** *(0.092)*			**-0.025** *(0.108)*	
Interaction (**Sectoral indebtedness** and **Product Market Regulation**)			**-0.002** *-0.071*			**0.001** *(0.085)*	
Interaction (**Sectoral indebtedness** and **Unexpected Drop in Yields**)				**0.282**** *(0.121)*			**0.275*** *(0.156)*
Interaction (**Sectoral indebtedness**, **Unexpected Drop in Yields** and **Product Market Regulation**)				**-0.212**** *(0.092)*			**-0.206*** *(0.118)*
Sectoral indebtedness	**more than one year maturity**		**-0.054** *(0.054)*			**-0.074** *(0.065)*	
Interaction (**Sectoral indebtedness** and **Product Market Regulation**)			**0.048** *-0.041*			**0.060** *(0.052)*	
Interaction (**Sectoral indebtedness** and **Unexpected Drop in Yields**)				**0.167** *(0.100)*			**0.177** *(0.114)*
Interaction (**Sectoral indebtedness**, **Unexpected Drop in Yields** and **Product Market Regulation**)				**-0.128** *(0.077)*			**-0.144** *(0.088)*
Sectors × Countries		35×7	35×7	35×7	35×7	35×7	35×7
Observations		220	220	220	220	215	215
R-squared		0.501	0.518	0.514	0.491	0.494	0.502

Note: Each column presents the estimation results from a cross-country cross-sector panel regression where the dependent variable is sectoral real value added growth over 2012-2014 and the explanatory variable are indicated in the first and second columns of the table. The lagged dependent variable is sectoral real value added growth over 2010-2012. Sectoral indebtedness is the log of bank debt to equity in 2012 (columns 1-3) or the log of bank debt and bonds to equity in 2012 (columns 4-6). Sectoral Indebtedness is computed using financial liabilities of all maturities (rows 2-3), of less than one year maturity (rows 4-5) or of more than one year maturity (row 6-7). The unexpected drop in yields is the difference between the average forecast error in 10-year government bond yields over 2013-2014 and the same average forecast over 2011-2012. Product market regulation is the average for 2013 of the state control index, the barriers to trade and investment index and the barriers to entrepreneurship index. Interaction variables are computed as the product of variables in parenthesis. All estimations include the full set of country and sector fixed effects. Standard errors are clustered at the sector level. ***/**/* indicate statistical significance at the 1/5/10% levels.

4.9.2 Financial Expenses

Up to now, we have shown that more indebted sectors, particularly those with short-term debts, tend to benefit disproportionately from lower government bond yields, particularly when product market competition is strong. This benefit materializes in terms of higher growth in real value added, labour productivity or capital productivity. The question that we now seek to answer is how lower funding costs translate in higher growth. One natural transmission channel relates to interest expenses: if firms can get better funding conditions, then their interest expenses should drop and the more so if their stock of debt is larger.

In this section, we aim at expanding the analysis of transmission channels. To do so, we proceed in two steps. First we investigate the role of liquid liabilities. Specifically we separate current and non-current bank debt (and bonds), i.e. less than one year of maturity and more than one year of maturity, and build two sector-level indicators of financial liabilities: (i) the ratio of current bank debt (and bonds)\ to equity; and

(ii) the ratio of non-current bank debt (and bonds) to equity. We hence run the following set of regressions

$$IP_{sc}^{13-14} = \alpha_s + \alpha_c + \beta_0 . IP_{sc}^{11-12} + [\beta_1 + \beta_{11} . (reg)_c] \times (debt)_{sc} + [\beta_2 + \beta_{21} . (reg)_c] \times (debt)_{sc} \times (omt)_c + \varepsilon_{sc} \quad (15)$$

where the dependent variable IP_{sc}^{13-14} is the log-average or the log-change in financial payments to equity over the period 2013-2014 and IP_{sc}^{11-12} is the same variable but measured over the period 2010-2012, other variables being unchanged. Estimation results reported in Table 7 show that persistence patterns are very different: average financial payments tend to exhibit significant time persistence but the change in financial payments has no persistence whatsoever. Second, the larger the drop in government bond yields, the larger the drop in the log-average or the log-change in interest payments to equity for more indebted sectors (second row in Table 7). This result seems totally intuitive. Moreover, consistent with previous results, a higher value of the product market regulation index tends to reduce the benefit of lower government bond yields in terms of reduced financial payments (second third in Table 7). Once again, this confirms that product market regulation tends to dampen the positive effect of easier funding conditions for more indebted sectors and this suggests that the channel through which that may take place is financial payments. Two hypotheses can be put forward to account for this result. On the one hand, this may be related to banks' behaviour: When firms have market power, banks may be incentivized to provide more stable funding conditions, meaning that banks smooth both tightening and easing episodes. Since we are looking at a particular case of easier funding conditions, this would mean that banks keep the benefit of lower funding costs instead of passing them on to final borrowers. On the other hand, it may also be that firms tend to hold more current debt when their market power is weaker. When competition on the goods market is strong, firms may find it more attractive to borrow over the short term as the risk premium on long term debt may be particularly high. In this case, refinancing would naturally tend to be easier to carry out and firms would benefit more from easier funding conditions when competition is stronger.

Table 7

Interest payments, financial conditions and product market regulation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	**Interest payments to equity**				**Change in interest payments to total equity**			
Lagged dependent variable	**1.011*** *(0.064)*	**0.999*** *(0.075)*	**0.964*** *(0.089)*	**0.968*** *(0.088)*	**0.061** *(0.148)*	**0.049** *(0.159)*	**0.030** *(0.155)*	**0.036** *(0.156)*
Interaction (**Sectoral indebtedness** and **Unexpected Drop in Yield**)	**-0.130**** *(0.053)*	**-0.127**** *(0.050)*	**-1.362*** *(0.690)*	**-2.254**** *(0.900)*	**-0.155*** *(0.078)*	**-0.150*** *(0.076)*	**-2.219**** *(0.945)*	**-3.435*** *(1.781)*
Interaction (**Sectoral indebtedness, Unexpected Drop in Yield** and **Product Market Regulation**)			**0.957*** *(0.515)*	**1.642**** *(0.679)*			**1.597**** *(0.696)*	**2.531*** *(1.352)*
Sectoral indebtedness	**-0.075** *(0.0614)*	**-0.480** *(0.657)*	**-0.104*** *(0.0545)*	**1.148** *(0.710)*	**-0.179** *(0.155)*	**-1.076** *(1.039)*	**-0.245*** *(0.131)*	**1.467** *(1.886)*
Interaction (**Sectoral indebtedness** and **Product Market Regulation**)		**0.302** *(0.517)*		**-0.948*** *(0.545)*		**0.664** *(0.836)*		**-1.296** *(1.455)*
Sectors × Countries	35×7	35×7	35×7	35×7	35×7	35×7	35×7	35×7
Observations	214	214	214	214	215	215	215	215
R-squared	0.773	0.774	0.784	0.788	0.460	0.463	0.483	0.489

Note: Each column presents the estimation results from a cross-country cross-sector panel regression where the dependent variable is average sectoral interest payments to equity over 2013-2014 (columns 1-4) and the change in sectoral interest payments to equity between 2014 and 2012 (columns 5-8). The explanatory variable are indicated in the first column of the table. The lagged dependent variable is the average sectoral interest payments to equity over 2011-2012 (columns 1-4) and the change in sectoral interest payments to equity between 2012 and 2010 (columns 5-8). Sectoral indebtedness is the log of bank debt to equity in 2012. The unexpected drop in yields is the difference between the average forecast error in 10-year government bond yields over 2013-2014 and the same average forecast over 2011-2012. Product market regulation is the average for 2013 of the state control index, the barriers to trade and investment index and the barriers to entrepreneurship index. Interaction variables are computed as the product of variables in parenthesis. All estimations include the full set of country and sector fixed effects. Standard errors are clustered at the sector level. ***/**/* indicate statistical significance at the 1/5/10% levels.

5 Conclusion

In this paper we developed a simple model in which firms can make growth-enhancing investment but are subject to liquidity shocks that forces them to reinvest money in their project. Anticipating this, firms may have to sacrifice part of their investment in order to secure reinvestment in case of a liquidity shock (liquidity hoarding). A countercyclical interest rate policy is therefore growth-enhancing as it helps firms reduce the amount of liquidity hoarding. Moreover our model predicts that such a policy is more growth-enhancing when the probability to be hit by a liquidity shock is higher and when competition is higher: indeed when competition is low, large rents allow firms to stay on the market and reinvest optimally, no matter how funding conditions change. Cyclical fluctuations matter less for firms holding monopoly power than for those facing tight competition.

We then confronted these predictions to the data using two alternative approaches. First, we looked directly at the interaction between growth on the one hand and credit-constraints and countercyclical monetary policy on the other hand. Then we found a growth-enhancing effect of more countercyclical monetary policies, which is stronger in industries that are more financially constrained and that kicks in particularly for countries with relatively strong competition on the goods market (where competition is inversely measured by the intensity of barriers to trade and investment). Second, we looked at the effect of unexpected drop in long-term government bonds following the announcement of OMT. Then we found that heavily indebted sectors benefited disproportionately from this unexpected drop, but only in countries where product market regulation is rather low.

Our analysis can be extended in several directions. A first extension would be to look at labour market regulation and see whether we find the same complementarity between a proactive monetary policy and labour market flexibility as the one we found in this paper between a proactive monetary policy and product market competition. A second extension which we are currently pursuing is to investigate the relationship between structural reforms and monetary policy stimulus using firm-level data and bank-firm matched data. In this project relying on French data, we follow Chodorow-Reich (2014) to build a firm-specific measure of financial constraint using bank-firm existing credit relationships. We then want to investigate the growth effect of quantitative easing by the ECB, which raises banks' profits through valuation gains on government bond holdings. Our conjecture is that firms borrowing heavily (little) from such banks benefit more (less) of a relaxation of their borrowing constraint. But this relaxation in financial constraints has translated into an increase in employment and capital expenditures only in the most competitive of sectors.

The Productivity Growth Slowdown in Advanced Economies

By Charles I. Jones[135]

Abstract

Perhaps the most remarkable fact about economic growth in recent decades is the slowdown in productivity growth that occurred around the year 2000. This slowdown is global in nature, featuring in many countries throughout the world. In this discussion, I summarize some important characteristics of the slowdown and consider recent insights from the growth literature on its possible causes.

1 Introduction

Many economic problems can be solved by economic growth. Most obviously, economic growth is almost definitionally related to improvements in living standards. Less obviously, problems with government budget constraints – and the issues related to sovereign defaults and even high inflation – may be relieved by economic growth. All of this makes the global slowdown in productivity growth since around the year 2000 one of the most significant economic issues confronting the advanced economies of the world today.

I begin my discussion by summarizing some of the key facts related to this slowdown. Next, I review the insights offered by the growth literature concerning how we might understand slowing productivity growth. Finally, I conclude by offering some thoughts on the prospects for growth in advanced economies in the coming decades.

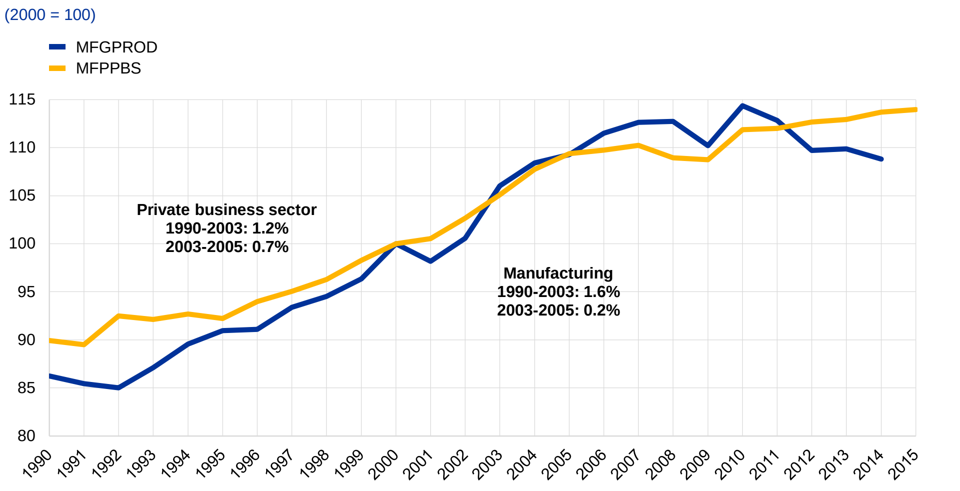
1.1 Basic Facts

Chart 1 shows the level of total factor productivity (TFP) for the U.S. economy since 1990, first for the private business sector and then for manufacturing. Splitting the sample in half reveals the slowdown. Between 1990 and 2003, TFP growth in the private business sector averaged 1.2 percent per year. Since 2003, however, the growth rate has slowed to 0.7 percent.

[135] Graduate School of Business, Stanford University. I am grateful to John Fernald, Loukas Karabarbounis, Pete Klenow, and Ricardo Reis for helpful comments and discussions in preparing this paper.

Chart 1

U.S. Total Factor Productivity



Sources: Bureau of Labor Statistics, "Multifactor Productivity Trends," downloaded from the Federal Reserve Economic Data database of the FRB St. Louis on June 12, 2017.
Note: Average annual growth rates over various periods are reported in the graph.

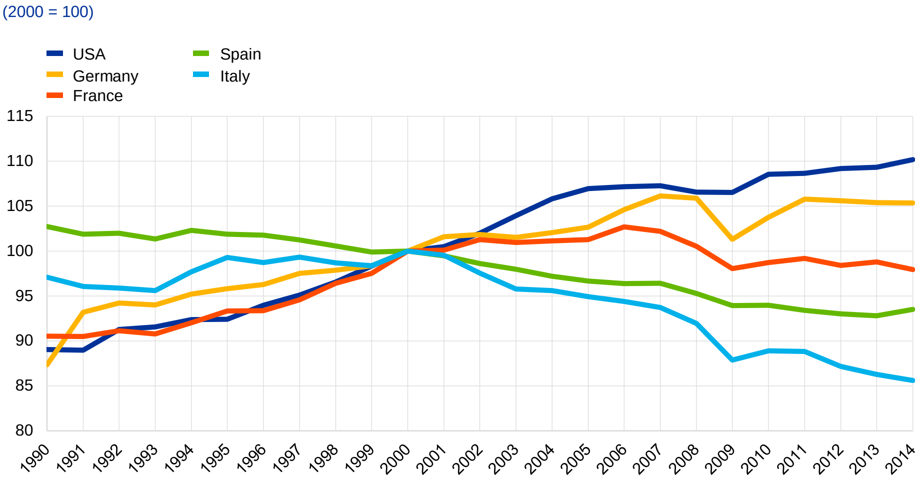
A common hypothesis for the slowdown is increasing mismeasurement, particularly associated with the "free" goods provided by IT firms like Google and Facebook. Byrne, Fernald, and Reinsdorf (2016) and Syverson (2017) conclude that the slowdown is so large relative to the importance of the "free" sector that mismeasurement is likely a small part of the explanation. Aghion et al. (2017) use firm-level employment dynamics to assess the mismeasurement of growth due to creative destruction. They find that growth is understated by around 0.5 percentage points per year, but they do not find a substantial change in mismeasurement over time.

The second line in Chart 1 – TFP in the manufacturing sector – reinforces this point. Manufacturing is one of the better-measured sectors in the U.S. economy and a traditional stronghold for productivity growth. Yet this sector exhibits an even sharper slowdown than the aggregate economy: from an annual growth rate of 1.6 percent between 1990 and 2003 to just 0.2 percent since 2003. The growth slowdown, then, appears to be real and economically important.

Chart 2 reports levels of total factor productivity for the U.S., France, Italy, Germany, and Spain using data from the Penn World Tables. These data correspond to the aggregate economy in each country, including the government sector.

Chart 2

Total Factor Productivity in Select Countries



Sources: Author's calculation using the Penn World Tables 9.0.
Notes: Based on the series "rtfpna".

The U.S. productivity slowdown is once again apparent in the chart. More remarkable, however, is that productivity growth since 2000 is even slower in the European economies. TFP is about 5 percent higher in Germany in 2014 than it was in 2000. But TFP levels in the remaining three countries are actually lower than they were in 2000: in France by about 2 percent, in Spain by about 5 percent, and in Italy by more than 10 percent. Therefore, it is not merely a slowdown in productivity growth that needs to be explained: we also need to understand how it is possible for some advanced economies to be substantially less productive today than they were in the year 2000.

1.2 How Growth Theory Can Explain These Facts

Modern growth theory views productivity as being determined by two main economic forces: ideas and misallocation.[136] In the seminal models put forward by Romer (1990) and Aghion and Howitt (1992), productivity growth results from the discovery of new ideas. A slowdown in productivity growth could then occur in two possible ways. We could be moving from a regime in which ideas were relatively easy to discover to one in which ideas are harder to discover, or we could – in some sense to be made more precise below – be investing fewer resources in the search for new ideas.

The second key force impacting productivity that has been highlighted in the growth literature is misallocation. Indeed, the insight that the misallocation of resources at

[136] A third possibility is suggested by Lucas (1988), namely that productivity can be determined by human capital investments. This explanation requires care in that many determinants of human capital are already incorporated into the inputs in the total factor productivity calculations, including formal schooling and demographics associated with age, gender, and occupation. However, human capital accumulation that is "within cell" so to speak – such as on-the-job training or learning-by-doing – could show up as productivity growth.

the micro level leads to declines in TFP at higher levels of aggregation is one of the key insights from the growth literature in the past decade. Restuccia and Rogerson (2008) emphasized this point conceptually, while Hsieh and Klenow (2009) studied its quantitative importance in accounting for TFP differences between the U.S., China, and India. Applied to the question at hand, a slowdown in TFP growth – or even a decline in TFP – could result from a systematic increase in the misallocation of resources at the microeconomic level.

The next two sections explore these possibilities in more detail.

2 Ideas and the Productivity Slowdown

At the heart of virtually all models of economic growth based on the discovery of new ideas is an equation like the following:

$$\text{Economic growth} = \text{Idea TFP} \times \text{Number of researchers}$$

That is, the growth rate of some economic entity (a firm, a product, or even the economy itself) arises through the discovery of new ideas. These ideas in turn are produced by research effort ("Number of Researchers") multiplied by their research productivity ("Idea TFP").

My latest research project – Bloom, Jones, Van Reenen, and Webb (2017) – studies this equation empirically at various levels of aggregation. For example, we've looked at the aggregate economy, at Moore's Law for the density of computer chips, at the productivity of various types of agriculture, at a range of medical innovations, and at firm-level data in Compustat. What we find everywhere is that growth rates are relatively stable, sometimes rising slightly, sometimes falling slightly, sometimes constant. But research effort increases dramatically. The implication is that research productivity – the TFP in the idea production function – is falling dramatically.

Two examples illustrate this point. First, for the aggregate U.S. economy, it is well known that growth rates of GDP per person are relatively stable over time; if anything, growth has slowed a bit recently. In contrast, research effort has risen by more than a factor of 20 since the 1930s. The implication is that Idea TFP has fallen by more than a factor of 20: it is more than 20 times harder today to generate exponential growth in the U.S. economy than it was in the 1930s.

A similar finding occurs with respect to computer chip density and Moore's Law. Recall that Moore's Law is the stylized fact that the density of transistors on computer chips doubles every two years, and this doubling time has been remarkably stable back to the 1970s. A constant doubling time of course corresponds to constant exponential growth, in this case at a rate of about 35 percent per year. How has this growth been achieved? Bloom et al. (2017) measure the research input in a variety of ways, but no matter how we do it, the finding is the same: the research required today to double computer chip density is much higher – perhaps by a factor of 15 or more – than it was in the 1970s. Once again, exponential growth is getting harder to achieve over time, and the way it is achieved is by committing ever increasing quantities of research effort to the endeavor.

The conclusion of that paper is that ideas are systematically getting harder to find, a conclusion reminiscent of Gordon (2016). Interestingly, however, the analysis suggests that this has always been true! In other words, there is nothing in our work arguing that anything has changed over time. It has always been getting harder and harder to find new ideas, and the exponential growth we see is the outcome of throwing more resources into research. So this particular story does not seem to be able to account for slowing productivity growth in advanced economies.

It does, though, suggest a possible alternative explanation. One model consistent with these facts might be called a “Red Queen” model of economic growth, after a character in Lewis Carroll’s Through the Looking Glass: “Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!” Constant exponential growth in research effort offsets its declining productivity. Continued growth in research inputs is required to generate exponential growth in the economy, and if the growth rate of research effort were to slow, the outcome would be a slower rate of exponential productivity growth.[137]

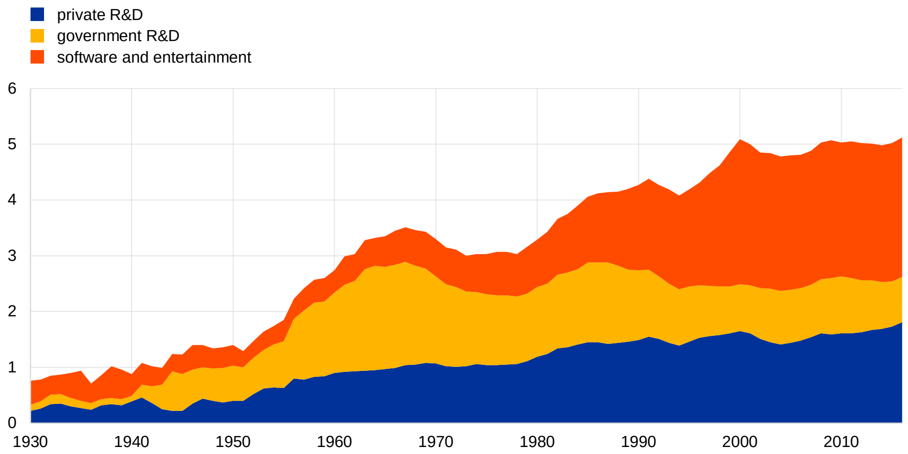
The next two graphs examine how resources devoted to innovation have changed over time. Chart 3 takes advantage of the recent revisions to the U.S. National Income and Product Accounts to show investment in “intellectual property products” (IPP) as a share of GDP. IPP includes public and private investment in research and development but also incorporates spending on other nonrival goods, including computer software, books, music, and movies.

[137] See Jones (1995) and Kortum (1997) for models along these lines. This literature is reviewed in Jones (2005).

Chart 3

U.S. Intellectual Property Products Investment

(share of GDP)



Sources: U.S. Bureau of Economic Analysis via FRED.

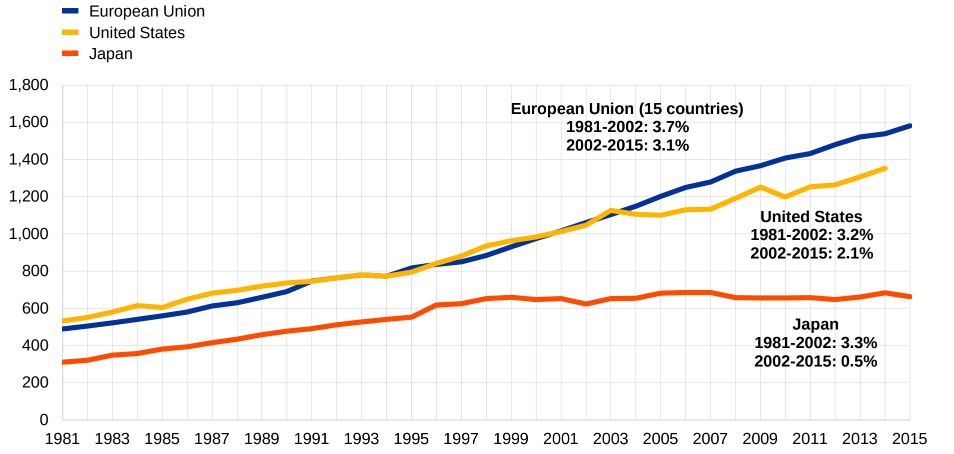
Several important facts are evident in Chart 3. First, there was a general rise in R&D spending as a share of GDP up until the mid-1960s. The rise in private R&D has continued though the present time, but public R&D as a share of GDP has been declining in general since the first astronaut set foot on the moon. Since 1980, investment in software and entertainment products has risen sharply. Taken as a whole, investment in intellectual property products has generally been rising over time as a share of GDP. However, since about 2000, the investment rate has been more stable.

The evidence from this chart about the Red Queen model is somewhat mixed. Private R&D appears to be growing in intensity. Private plus public R&D shows no trend or change in trend since around 1980. Finally, the total IPP investment rate does appear to have changed behavior in the last two decades, stabilizing rather than continuing to rise.

It is important to appreciate, of course, that the search for new ideas is a global phenomenon. The United States benefits from ideas created all over the world, as do all other countries. Chart 4 shows research employment in the European Union, Japan, and in the United States since 1981 and reveals an interesting finding.

Chart 4

Research Employment in the E.U., the U.S., and Japan



Sources: OECD Main Science and Technology Indicators.
Note: Average annual growth rates over various periods are reported in the graph.

All three measures of research employment show a slowdown in research effort. After growing at 3.7 percent per year between 1981 and 2002, for example, research employment in the E.U. grew at only 3.1 percent between 2002 and 2015. The slowdown in research in the United States is even larger: from an average growth rate of 3.2 percent before 2002 to just 2.1 percent after. Finally, the slowdown in Japan is especially noteworthy. Research employment grew at 3.3 percent per year before 2002 but just 0.5 percent after. Remarkably, research employment in Japan has been relatively stable since the late 1990s. According to the logic of the Red Queen model, this slowdown in the growth rate of research effort should translate into a slowdown in productivity growth. Slowing research effort, then, is a possible explanation for the productivity slowdown. This hypothesis should be explored further in future work.

3 Misallocation

A key contribution of the growth literature of the past decade is a renewed appreciation of the importance of the misallocation of resources in the determination of aggregate TFP. The level of TFP is simply a measure of how successful a given basket of aggregate inputs, including capital, labor, and human capital, are in production. When resources are misallocated at the microeconomic level, it is easy to show that this will reduce TFP at a more aggregated level; for example, see Restuccia and Rogerson (2008) and Hsieh and Klenow (2009) for precise statements along these lines. This misallocation could occur across sectors, across firms within a sector, or even within a firm itself. For example, a housing bubble will provide agents in the economy with mistaken price signals that will lead to too many housing being built at the expense of other economic activity. This misallocation across sectors would reduce aggregate TFP. Alternatively, privileged access to credit by some firms at the expense of others could result in the misallocation of resources within a narrowly defined sector. This would reduce the TFP of that sector and therefore also contribute to lower aggregate TFP. Finally, poor management practices could result in the misallocation of resources within a firm. In some ways, this is a natural explanation for TFP differences across firms: as has been long appreciated, firms are in some respects like centrally planned economies, and the absence of markets inside firms can make it particularly difficult to allocate resources optimally. Good management practices contribute to good allocations, while bad management practices lead to misallocation and reduce firm-level TFP.

Misallocation is a particularly appealing hypothesis for explaining the decline in aggregate TFP that we've seen in economies like Italy and Spain. It is not plausible that these economies are forgetting knowledge, so the idea-based models have a hard time explaining a decline in TFP. But an increased misallocation of resources – perhaps because of the housing bubble and frictions associated with the financial crisis – offers a possible explanation. And of course an increase in misallocation in the United States could contribute to slowing productivity growth there as well.

A number of papers have attempted to measure the macroeconomic consequences of misallocation. These papers build on a simple insight. In particular, the efficient allocation of resources requires that the value of the marginal product of labor, for example, be equated across firms. Any deviation from this equality implies that reallocation can improve productivity by moving labor from a place where it has a low marginal product to a place where it has a high marginal product. Similar statements apply to capital or intermediate inputs or any other input. Therefore, variation in the marginal revenue product of an input across firms is one summary statistic commonly reported in the literature on misallocation. Moreover – and relying on important structural assumptions such as the precise form of production functions – one can calculate the implied gain in output that could be achieved by eliminating the variation in marginal revenue products across firms or plants. With this approach, Hsieh and Klenow (2009) argue that total factor productivity in the manufacturing sector in China and India would be about 50 percent higher if the marginal revenue products of capital and labor were equated across firms within relatively narrow 4-digit industries.

More recently, research has turned to measuring the extent to which misallocation has changed over time. Reis (2013) noted that productivity growth slowed sharply in Portugal and several other economies of southern Europe after they joined the euro. He proposed that the misallocation of the large capital inflows that followed the adoption of the common currency could be part of the explanation. This hypothesis has been explored in more detail using micro data in recent research. Gopinath, Kalemli-Ozcan, Karabarbounis, and Villegas-Sanchez (2017) use the Orbis database to study misallocation in the manufacturing sector in Spain and several other countries of southern Europe. They show that the dispersion in the marginal revenue product of capital increased significantly in Spain between 1999 and 2012, potentially accounting for a 7-12 percent decline in manufacturing TFP relative to trend. With less complete data, they document similar results for Italy and Portugal. Interestingly, they do not find a substantial increase in misallocation in France, Germany, and Norway.

Other authors with access to administrative data have now gone further and studied misallocation across firms throughout the economy, not just in manufacturing. These papers provide fairly consistent support for the misallocation hypothesis as an important factor in explaining slow and even declining TFP in southern Europe.

Bils, Klenow, and Ruane (2017) examine changing misallocation within the manufacturing industries in the United States and document two important findings. The first is perhaps surprising: applying the basic techniques of Hsieh and Klenow (2009) to U.S. manufacturing over time, they find a large increase in misallocation between 1978 and 2007. In particular, their basic calculation suggests that U.S. manufacturing efficiency was only 2/3 of its maximum level in 1978 and that this fell to just 1/3 by the mid-2000s. Taken at face value, this implies that rising misallocation could be an important contributor to the slowdown in manufacturing productivity growth.

Their second finding, however, casts doubt on their first. In particular, it has long been appreciated that measurement error is a significant problem for judging the importance of misallocation. The key contribution of Bils, Klenow, and Ruane (2017) is to provide a statistical technique that controls for measurement error. In particular, they argue that additive measurement error that is constant can be “differenced out” by looking at changes in inputs and outputs over time in order to compute marginal products. They use this basic insight to show how even time-varying measurement error can be controlled for, at least when it is of an additive form. Applying this correction to U.S. manufacturing, they suggest that allocative efficiency is roughly 80 percent of its optimal level and, importantly, that the degree of misallocation is relatively stable over time. The implication is that measurement error in U.S. manufacturing data has been rising over time.

Several important directions for future work are implied. First, what accounts for the increase in measurement error over time in the U.S. data? Second, given that measurement error is obviously important, are there techniques that can control for multiplicative measurement error (which is arguably more natural) and not just additive measurement error? Finally, do the results in the various European countries look different if one adjusts for measurement error?

4 Future Prospects

What about the prospects for productivity growth in advanced countries in the coming decades? I offer three observations.

First, if one of the explanations for slowing productivity growth at the frontier is a slowdown in the growth rate of research inputs, then a natural question to ask is “Why?”. What economic forces are behind the slowdown in research, and can these be reversed in the future? I do not know the answer to this question, but it is clearly important. One observation, based on Chart 3, is that public funding for basic research has declined significantly when expressed as a share of GDP.

Understanding the role that this may have played in the latest productivity growth slowdown strikes me as quite important.

Second, I already observed that the search for new ideas is a global phenomenon. Because of the diffusion of technologies, ideas invented anywhere in the world ultimately benefit people in countries that are open to the international flow of ideas. Along these lines, the rise of research in China and India as these economies develop may be central in driving the future growth rate of global research effort. Each of these economies by themselves has as many people as the United States, Western Europe, and Japan combined. How many Edisons and Einsteins have we missed in the previous century because of the lack of economic development in China and India? And how many more will they contribute in coming decades as their development proceeds?

Finally, to the extent that increases in misallocation have reduced total factor productivity in some of the countries in Europe, it should be appreciated that this is a “level effect” and not a “growth effect.” In other words, productivity growth will surely resume in these countries eventually. Nevertheless, once that resumption occurs, we should not stand by and be satisfied. If misallocation permanently reduces the level of productivity relative to trend by 15 percent, the damage is done. Understanding the economic forces that have caused such a loss is critical so that the misallocation can be reversed.

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INVESTMENT AND GROWTH
IN ADVANCED ECONOMIES
ECB FORUM
ON CENTRAL BANKING
RESERVED
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Making the European semester more efficient

By Agnès Bénassy-Quéré[138]

Abstract

The "European semester", which spans from November of year N-1 to May of year N, aims at organizing economic policy coordination among the Member States of the European Union, along three axes: the Stability and Growth Pact, the macroeconomic imbalances procedure, and the Europe 2020 Integrated Guidelines. However the process is highly complex. To make it more efficient, we suggest to separate the three axes depending on explicit objectives and instruments. Specifically, the macroeconomic imbalances procedure could be refocused on its initial objective: preventing the building up of large imbalances in the private sector (the public sector being covered by the Stability and Growth Pact), and on policy instruments that can be activated "at the margin", delivering in the short and medium term.

1 Introduction

In 2011, the European Semester was introduced to improve the effectiveness of the coordination of national economic policies. Prior to this date, economic policies were loosely coordinated through the Broad Economic Policy Guidelines (BEPGs, see Art. 121.2 of the TFEU) and Employment Guidelines (EGs, see Art. 148 of the TFEU) – an annual, relatively formal exercise. The objective of the European Semester is to transform BEPGs and EGs into a binding process through encapsulating three instruments: the Stability and Growth Pact (SGP), the macroeconomic imbalances procedure (MIP) and the Europe 2020 "Integrated Guidelines". Of these three processes, two may involve sanctions for euro area Member States if the recommendations are not followed by decisive action. Here we concentrate more specifically on the macroeconomic imbalances procedure (MIP).

[138] Paris School of Economics, University Paris 1, and French Council of Economic Analysis. Research assistance from Amélie Schirich-Rey is gratefully acknowledged.

2 The macroeconomic imbalances procedure (MIP)

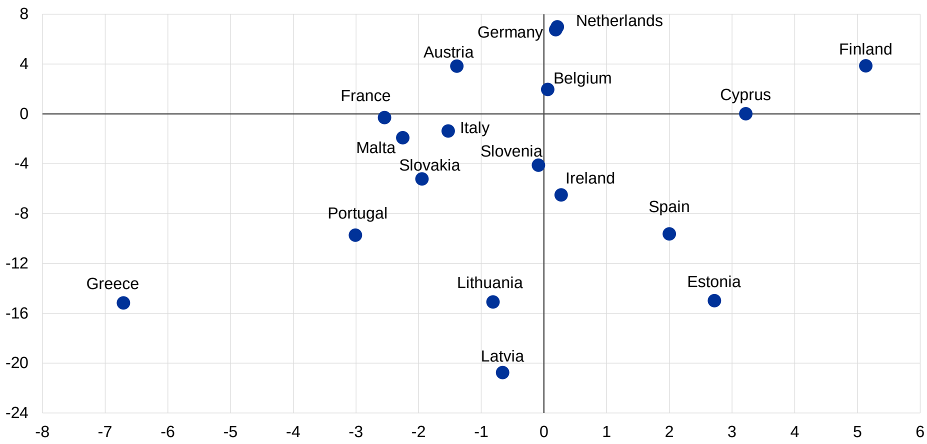
2.1 Why the MIP?

The introduction of the macroeconomic imbalances procedure (MIP) follows logically from the euro area crisis. On the eve of the global financial crisis, among the 19 countries of the current euro area, only Greece had a budget balance exceeding 3% of GDP.[139] However, all countries facing severe financial crises experienced current external deficits exceeding 6% of GDP (Chart 1). These deficits reflected a rapid rise of private sector indebtedness, in particular for banks.

Chart 1

Budget balance and current account balance of 19 European countries in 2007

(% of GDP; x-axis: budget balance; y-axis: current account balance)



Source: European Commission, Ameco database.

After having acknowledged that compliance with the SGP was by no means a sufficient protection against crises, the European partners introduced a macroeconomic imbalance procedure (MIP) on the occasion of the "six pack[140]" to monitor imbalances that are not related to the public sector. Incorporated in the European semester, the procedure starts at the end of year N-1 with the publication by the European Commission of an "Alert mechanism report" which, based on a set of indicators gathered in a scoreboard, designates a group of countries likely to present imbalances. In the spring of year N, the Commission then publishes an in-depth review for each of these designated countries.[141] It then classifies them into four categories (initially five): "no imbalances", "imbalances", "excessive imbalances", or "excessive imbalances requiring the activation of the excessive imbalance procedure". The latter category may lead to sanctions.

[139] This size of the Greek deficit was not yet known at that time.

[140] Legislative package consisting of five regulations and a directive adopted in October 2011.

[141] In-depth reviews are now incorporated in the country reports.

2.2 The 2017 vintage of the MIP

For the 2017 round of the MIP procedure, the European Commission carried out 13 in-depth reviews (out of the 28 EU Member States). Out of these 13 countries, it ranked 1 country in the “no imbalance” category, 6 (including 5 in the euro area) in “imbalances”, 6 (including 4 in the euro area) in “excessive imbalances” and none in “excessive imbalances requiring corrective action”. Table 1 summarizes the grievances addressed to the 9 euro area countries classified as presenting (excessive) imbalances. They mainly concern indebtedness (public and private), non-performing loans, external imbalances, competitiveness and unemployment.

Table 1

Origin of macroeconomic imbalances in 2017 according to the European Commission’s in-depth reviews

Countries experiencing “imbalances”	Countries experiencing “excessive imbalances”
Germany: excessive current external surplus, insufficient public investment	**France:** lack of competitiveness and productivity, public debt
Ireland: persistent public and private indebtedness	**Italy:** lack of competitiveness and productivity, public debt, fight against corruption and tax evasion, non-performing bank loans, unemployment
Spain: persistent public and private indebtedness	**Cyprus:** external deficit, non-performing loans, deficiencies in justice
The Netherlands: excessive current external surplus, private indebtedness	**Portugal:** public and private debt, non-performing loans, unemployment, lack of productivity
Slovenia: banking sector weakness, private indebtedness	

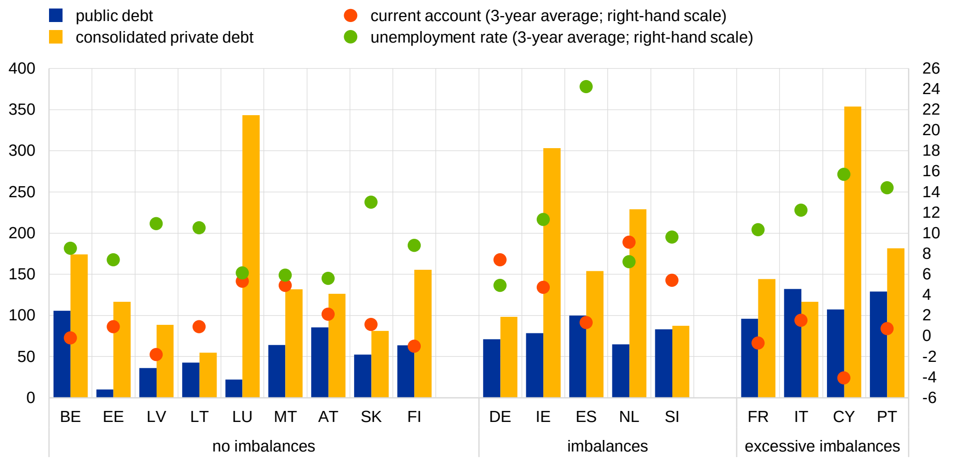
Source: European Commission (2017a), annex 3.

Four of the “main” indicators in the scoreboard are shown in Chart 2 for each of the three groups of countries in the euro area (excluding Greece[142]): no imbalances (including those countries not subject to an in-depth review), imbalances, and excessive imbalances. Countries with excessive imbalances are characterized by relatively high levels of unemployment and public debt. In general, the countries with imbalances show a large current account surplus. However, exceptions in each group do exist; therefore these four indicators are highly insufficient to understand the imbalances pointed out by the European Commission, which also concern non-performing loans, property prices, etc. However, the multiplication of criteria results in a certain lack of predictability for national governments. Conversely, the presence of public debt as a major criterion of the MIP raises the question of the interplay between the MIP and the SGP.

142 Greece is subject to a separate monitoring procedure under the programs of the European Stability Mechanism.

Chart 2

Four indicators of the 2017 scoreboard (% of GDP)



Source: Macroeconomic imbalances procedure, data based on end-2015 statistics.

The final stage of the procedure is the formulation of recommendations to the Member States in May of each year. Table 2 summarizes the country-specific recommendations to the four countries considered "in excessive imbalances" in the 2017 vintage of the MIP. All of them include fiscal adjustment, which is already monitored under the SGP. Some of them mention instruments that can be activated "at the margin", such as tax cuts, public investment or the evolution of the minimum wage. However, the recommendations under the MIP heading also cover a number of structural reforms (such as the reform of vocational training, or of collective bargaining rules) that can hardly be implemented (and can even less deliver results) over a one-year window.[143]

Table 2

Country-specific recommendations to the four countries considered "in excessive imbalances" in the MIP 2017

France: fiscal adjustment, tax cuts/base broadening, vocational education & training, minimum wage, regulatory burden
Italy: fiscal adjustment, efficiency of justice, competition laws, NPLs, insolvency, collective bargaining, social spending
Cyprus: fiscal adjustment, justice, insolvency, NPLs, public invest., education, employment service
Portugal: fiscal adjustment, open-ended contracts, NPLS, SME financing, administrative burden, insolvency

Source: European Commission (2017a), annex 3. NPLs: Non-performing loans.

2.3 Clarifying the surveillance processes

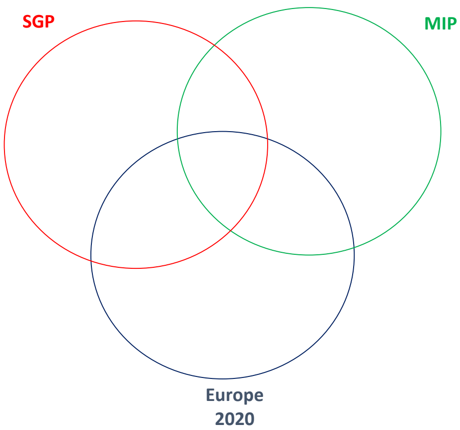
Perhaps because the MIP is perceived as more binding than the Europe 2020 integrated guidelines, most of the country-specific recommendations tend to be grouped under the MIP heading when countries are considered with imbalances or

143 Of course, the divide between "at the margin" and "structural" reforms may sometimes be blurred, as it is the case for the treatment of non-performing loans, which is closely related with insolvency and foreclosure procedures.

with excessive imbalances. In 2016, for instance, France received several recommendations under the MIP for structural measures relating to the labour market: apprenticeship, unemployment insurance, and labour laws. Simultaneously, Slovakia, which was considered to be with “no imbalances” (and not even subject to an in-depth review), also received recommendations for structural reforms related to the labour market. Ultimately, the labelling of the different types of recommendations appears somewhat arbitrary and their overlapping is detrimental to the overall readability of the scheme (Chart 3).[144]

Chart 3

Three overlapping surveillance processes



The objective of the SGP is fiscal discipline. The MIP was introduced in 2011 in order to supplement the SGP so as to avoid the accumulation of risks outside the public sector: corporate debt, household debt, banks’ fragility, housing bubbles, labour cost divergence, etc. The objective of the MIP was initially short and medium term. The policy instruments then would be instruments that can be changed rapidly “at the margin”, e.g. the minimum wage and remuneration of civil servants, tax rates, or macro-prudential policies. The European Union’s growth strategy aims at full employment and productivity growth, hence it has a long-term objective. The corresponding instruments are structural. In some cases, structural reforms may help achieve a medium-term objective. For instance, more flexibility in real estate and housing supply regulations may curb a housing bubble; likewise, reducing the duality of the labour market may limit wage growth.[145] In general, however, structural reforms only deliver after several years, so they cannot be relied on for the building up of short and medium term risks. Furthermore, mixing up structural reforms with policies that can be activated “at the margin” encounters the risk of repeating the same recommendation year after year, since structural reforms are typically implemented over a multi-year window.

[144] The poor implementation of the recommendations has been highlighted by Alcidi and Gros (2015) and Darvas and Leandro (2015).

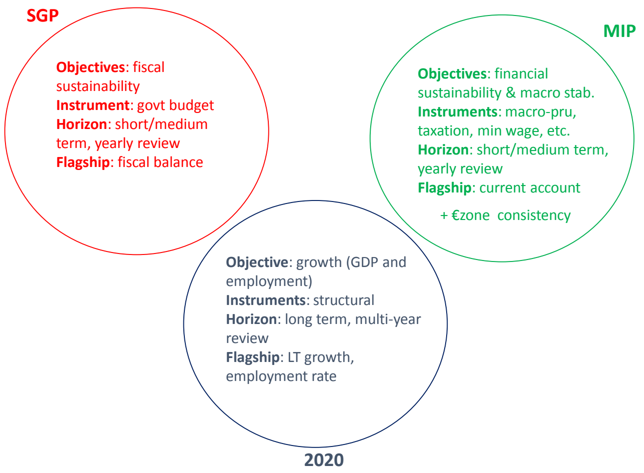
[145] More generally, the lack of growth in a highly indebted country raises the probability that the debt becomes (or is perceived as) unsustainable.

Burdening the MIP with structural, long-term issues has turned the MIP into a complex, blurred process. A way to restore the MIP as a frontline instrument would be to re-focus it on its initial objective: prevent the building up of macroeconomic imbalances that could degenerate in a severe crisis. In order to improve the overall readability of the scheme (and its appropriation by national governments and parliaments), the current account could be used as a flagship indicator, like the fiscal deficit for the SGP. For sure, there are "good" and "bad" current account imbalances. Looking back at Chart 1, though, it is quite clear that a large deficit tends to signal a risk of crisis. Conversely, a large surplus within a monetary union tends to put some deflationary pressure on the union since the domestic currency cannot appreciate. Countries with large current-account imbalances would then be scrutinized by the Commission through in-depth reviews that would study whether these imbalances are actually worrying or not.[146] Consistently, the policy recommendations under the MIP heading would concentrate on instruments that can be changed "at the margin". One difficulty is that macro-prudential instruments are activated following an entirely separate process with independent macro-prudential authorities at national level and the European Systemic Risk Board at European level. Some institutional adjustment may be required to incorporate the assessment of these different institutions into the country-specific, MIP recommendations.

Structural reforms would then be monitored under a separate process, with possibly multi-year objectives and surveillance, and a clear objective of raising productivity growth and employment rates (see Chart 4).

Chart 4

Towards a clarification of macroeconomic surveillance processes



[146] Similarly, in the macro-prudential surveillance, the "Basel gap" (the gap between credit-to-GDP and its trend) is examined first, before judgement is exerted to confirm or relativize the scope of this synthetic indicator.

Refocusing the MIP along the lines suggested in Chart 4 could help make it more operational and efficient, and especially more coherent for the euro area as a whole, as illustrated by the case of Germany and France in 2017 (Box 1).

Box 1
Macroeconomic imbalances: the case of Germany and France, 2017

The German current-account surplus and French current-account deficit provide a nice case study for the coherence of the MIP. Country-specific recommendations for Germany in 2017 have insisted on the need to "Use fiscal policy to support domestic demand and achieve a sustained upward trend in investment". This would be achieved through higher public investment, but also by "further improving the efficiency and investment-friendliness of the tax system and stimulating competition in business services and regulated professions". The Commission also recommended to "create the conditions to promote higher real wage growth".

In contrast, France was asked to further consolidate its public finances and its measures to reduce the labour cost, to "ensure that minimum wage developments are consistent with job creation and competitiveness". Like Germany, France was also required to "continue to lift barriers to competition in the services sector".

These recommendations are broadly in line with the view that reducing the German current-account surplus would require higher aggregate demand, whereas reducing the French current-account deficit would require higher aggregate supply. Furthermore, the recommendations correctly identify the non-financial corporate sector in Germany as one major contributor of the German surplus.

However, the steady rise in Germany's non-financial corporate excess savings since 2008 – from approximately −1% of GDP in 2008 to +3% of GDP in 2015 (see European commission, 2017b p. 7), has resulted from a rise in gross savings much more than from a decline in gross investment. In fact, the decline in corporate investment in Germany dates back to the beginning of the 2000s. The ability of public policies to raise the level of investment may then be questioned. Another way to boost aggregate demand in Germany would be to shift some purchasing power from non-financial companies to households, especially at the lower end of the remuneration schedule. This is the spirit of the recommendation to "create the conditions to promote higher real wage growth". However, real wage growth could be obtained by lower inflation (given the liberalization of the services sector) rather than through higher nominal wage growth, in which case such evolution would go against the recovery of inflation in the euro area. Additionally the recommendation of "further improving the efficiency and investment-friendliness of the tax system" may go against the objective of shifting some purchasing power from the companies to the households.

On the whole, whereas the recommendations to France are clearly (and correctly) supply-side, it is not clear that the recommendations to Germany are entirely demand-side. Additionally, the impact of the different recommendations on euro area aggregates is not clear-cut. Refocusing the MIP as explained in the text would streamline the process and make the implications of the different recommendations on basic supply-demand imbalances more apparent.

Source: European Commission, country-specific recommendations, 2017.

2.4 Conclusion

Economic governance in the euro area has become extremely complex, which reduces national ownership: national governments and parliaments already find it difficult to master the SGP rulebook; when it comes to the MIP, which is a multi-dimensional process, they generally have at best a vague understanding of it. This situation makes the implementation of a coherent macroeconomic strategy very difficult in the euro area, and the lack of readability also contributes to citizens' perplexity. Still, the European semester could be made much more efficient with the existing tools, provided a clarification is made and each procedure (SGP, MIP and Europe 2020 guidelines) is re-focused on a small number of objectives with the corresponding instruments.

Macroeconomic policy coordination will always remain difficult between sovereign states. This difficulty raises the case for some euro area-wide instruments, such as a counter-cyclical euro area budget (e.g. in the form of a supplementary unemployment insurance scheme in the spirit of the US system). After all, the euro was created inter alia as a way to overcome the difficult coordination of national monetary policies (through the European monetary system). It is not really surprising that the failure of policy coordination in other key areas raises the case for some form of integration.

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Fiscal consolidation and reforms: trade-offs and complementarities

By Marco Buti[147]

Structural reforms and fiscal consolidation went hand in hand over the crisis period. Will the better economic times lead to a change of approach? A number of elements indicate that, after the complementary relationship between reforms and consolidation observed in past years, a substitution relation may start prevailing in the years ahead.

The debate on the relation between fiscal consolidation and reforms is not new, but is acquiring new relevance in the current context. On the one hand, bringing back debts to prudent levels has become more urgent, because debt levels have become higher after the crisis, and nominal growth has fallen. On the other hand, the projected reduction of the growth potential gives structural reforms a key role to re-launch growth and make public finances sustainable looking forward.

The point I want to make during my intervention is that, while we have seen consolidation and reforms going hand in hand in Europe in the years following the financial crisis, this can change in the years to come. In this perspective, an appropriate application of the EU fiscal framework will be needed, joint with other surveillance and governance instruments.

Several ideas have been floated in the debate regarding the relation between consolidation and reforms.

At the time where EU countries were focused on Maastricht convergence, two camps were already clear on the debate: one camp emphasizes that consolidations and reforms where both necessary and that there was no alternative to doing both at the same time when markets have put countries with their "back against the wall" (e.g., Bean, 1998; Calmfors, 2001); the opposite camp highlights a substitution relationship linked to temporary output losses associated with reforms (e.g., Hughes-Hallett et al., 2004; Banerji et al., 2017) or to that fact that the political capital available to governments is limited, and that there are limits to the extent to which governments can undertake unpopular measures (e.g., Eichengreen and Wyplosz, 1998; Beetsma and Debrun, 2004; Delpla and Wyplosz, 2007).

Most likely, both views have an element of truth, and either one or the other can prevail, depending on the conditions. I have shown in a paper some years ago that complementarities are more likely to prevail when governments' time horizon is short. In that case, if market or rules-based fiscal constraints start binding, reforms

[147] European Commission, Directorate General of Economic and Financial Affairs.
I would like to thank Alessandro Turrini for help in preparing this intervention.
The views expressed in this paper are those of the author and do not reflect necessarily those of the European Commission.

are the only instrument left to foster growth in the short-to-medium term (Buti et al., 2009).

The arguments debated among economists have recently surfaced in the policy debate. For instance, the German Finance Minister Wolfgang Schäuble has recently stressed that fiscal consolidation and reforms are both needed looking forward, and that they will either come together or none of them will come depending how effective markets and institutions can be effective in providing incentives and winning moral hazard.[148]

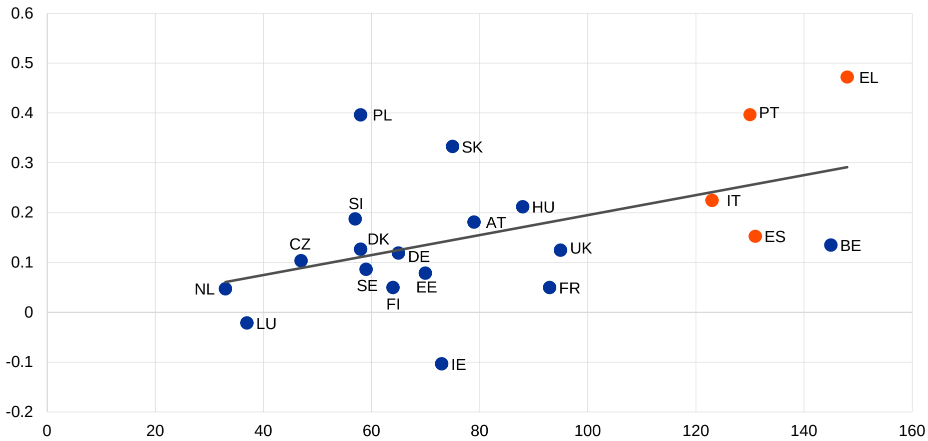
This is indeed a crucial question in the current context, and I would like to elaborate some arguments that can help us finding an answer.

What does the evidence suggests us? Crisis-hit countries took action aimed both at restoring budgetary equilibrium and reforming the economies to foster rebalancing and strengthen growth. Actually, after a stall in reform activism during the first EMU decade, crisis-hit countries were the most active in reforming product and labour markets since the crisis erupted (Chart 1).

Chart 1

Product and labour market reforms over the crisis period

(x-axis: labour market reform effort 2008-13; y-axis: product market reform effort 2008-13)



Sources: Elaborations on LABREF Commission database and OECD PMR data.

During the crisis, the same countries that were most active in reforming their economies were also those mode decisively taking measures to improve their budgets. Think of the countries that had to apply for financial assistance. Those countries had to cut budget deficits and reform their economies at the same time to foster their rebalancing and create the conditions for a more sustainable export-led growth. The threat posed by markets put governments' back against the wall, and facing the emergency required taking action of both fronts: public budgets and reforms.

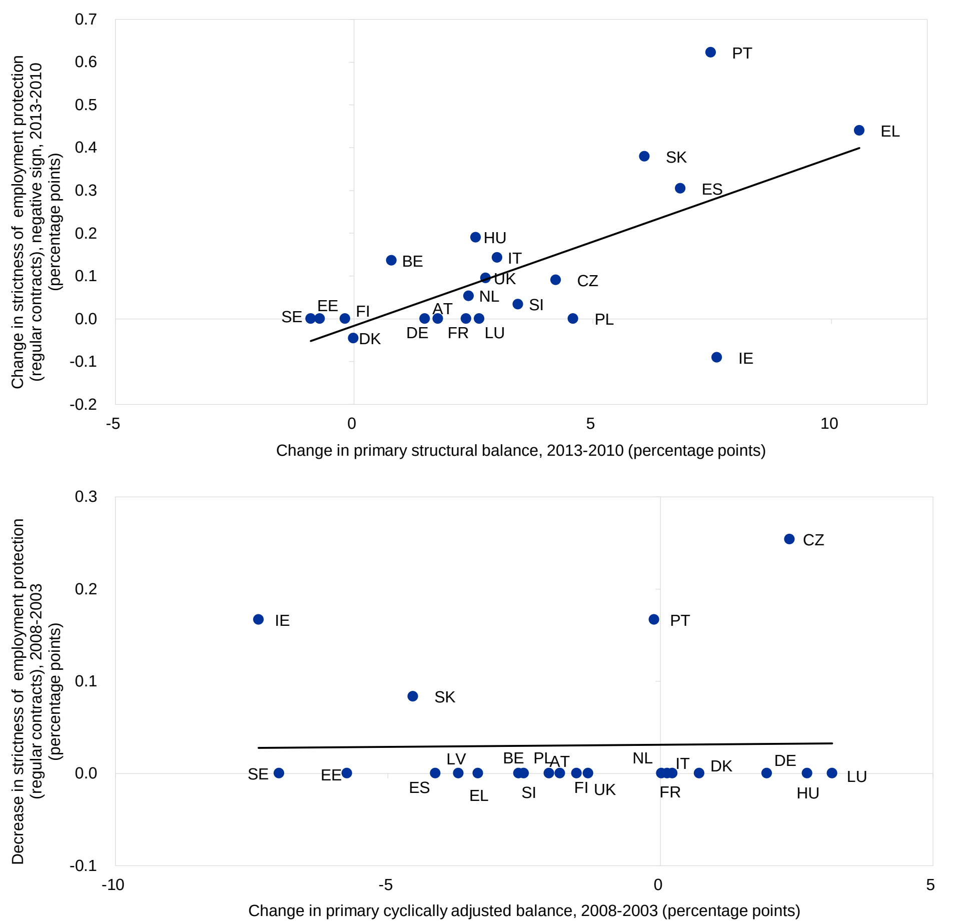
148 "Growth and Austerity: Can the Eurozone Have Both?", a Bertelsmann Foundation event in Washington, DC on October 9, 2014

The case is particularly evident when considering measures aimed at making the labour market more flexible. Chart 2 puts in relation the fiscal effort, measured by the change in the primary structural balance, and the change in the OECD EPL indicator. It is visible that over the crisis period the strongest EPL cuts are recorded by the countries where the improvements in the structural balance where the strongest, a relation that was instead not present in the pre-crisis period.

However, things seem to have changed after the easing of market-induced discipline. Reform fatigue seems to be prevailing in those Member States where many reforms took place. At the same time, large economies which have been relatively less hit by the crisis still need to reform. Overall, reforms are losing momentum and major budgetary adjustments are over. Are we at the beginning of a new phase, with both less consolidation and less reforms?

Chart 2

Fiscal consolidation vs. EPL reforms in crisis and non-crisis periods



Sources: elaborations on OECD and AMECO data.
Notes: Data on structural balances are not available before 2010. EPL changes are reported with negative sign, so that positive changes indicate a reduction in the degree of stringency of EPL.

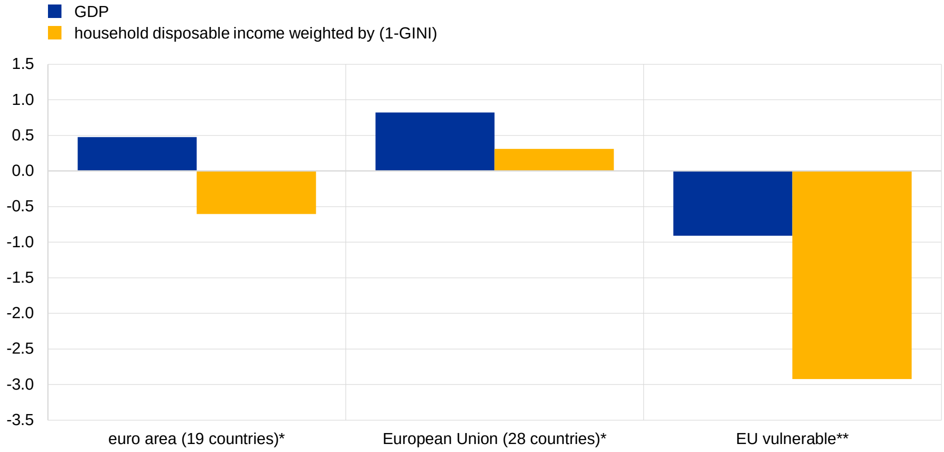
In my view, it is not at all obvious that consolidation and reforms will still go hand in hand going forward. A number of key conditions have changed as compared with the post-crisis period.

First, the crisis has eroded the social fabric in a number of EU countries. As shown in Chart 3, EU growth appears very different when measured in terms of household disposable income and taking into account the growing concentration of income in few hands. In such a context, the redistributions of income operated by fiscal consolidations and certain structural reforms in some cases contribute to deteriorate governments' political capital. Addressing inequalities and social exclusion is becoming a priority and poses constraints to policy maker. Including in light of recent reforms streamlining the welfare state, the room for reforms reducing the generosity of welfare payments has narrowed.

Chart 3

Per-capita GDP vs. household disposable income weighted by the Gini index

(average annual growth rate, 2010-2015)



Sources: Elaborations on Eurostat data.
Notes: + Adjusted net disposable income of households in real terms per capita (nominal values deflated using CPI),
* MT, LU, and HR dropped due to missing data,
** Simple average of CY, EL, ES, IE, IT, SI, and PT.

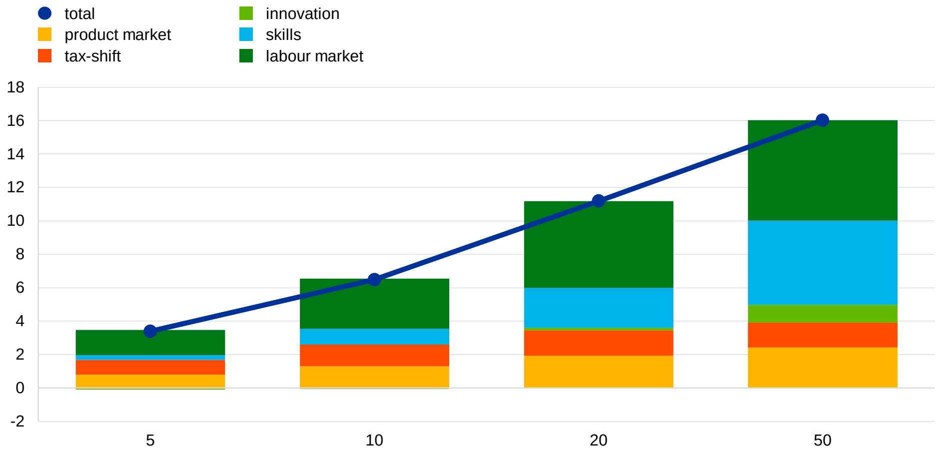
Second, the reforms that are most needed to restore address the fall in productivity growth in advanced economies are likely to cost on the budget. I am talking about human capital formation, and the tangible and intangible investment necessary to maintain and improve innovation rates and ensure the adoption of new technologies (OECD 2015, 2017). Macro model simulations show that the main sources of unexploited growth gains are labour market reforms (mainly reforms enhancing labour participation) and human capital formation reforms. In the longer-run, the majority of additional growth would be obtained via more effective mechanisms for the generation of human capital and skills (Chart 4). These are the reforms that permit to obtain a gradual but persistent improvement in TFP growth.

Chart 4

Closing ½ gap with best performers: GDP impact

EU28

(change from baseline, percentages)

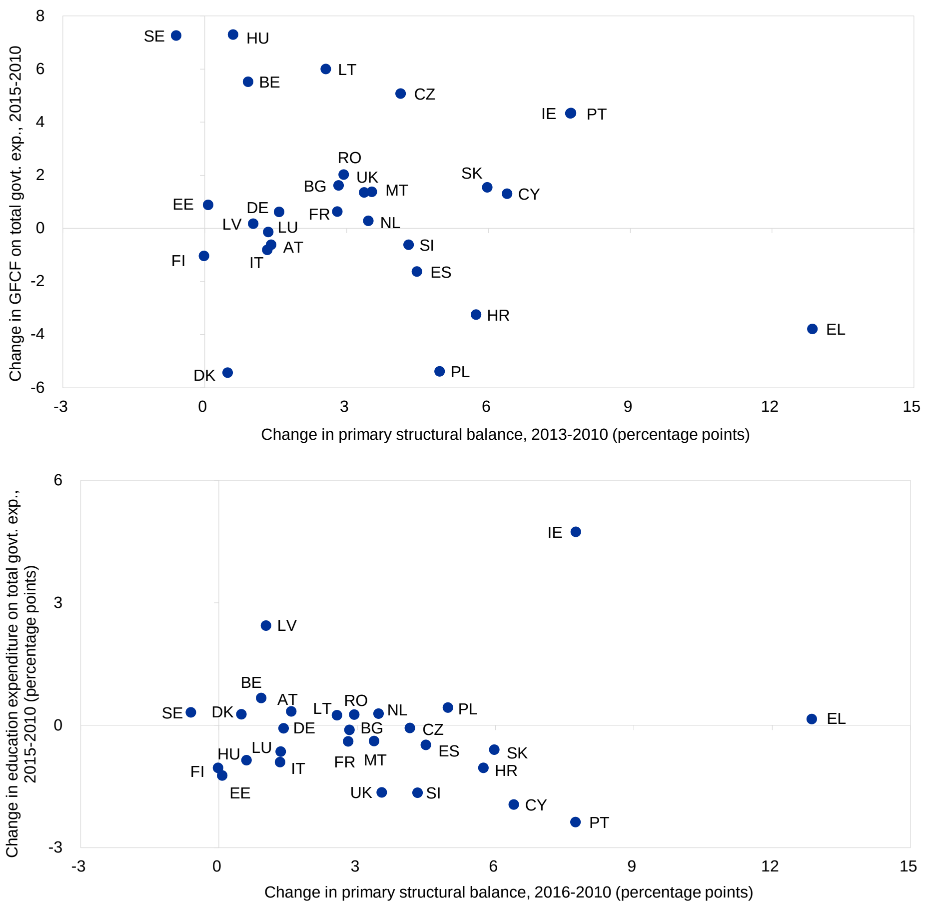


Sources: QUEST simulations, see Varga and in't Veld, 2014.

Finally, recent consolidation measures have sometimes implied reducing growth-friendly expenditure, such as infrastructure investment and to some extent education (Chart 5). The implication is that the room for further cuts in these items has reduced, creating in this respect a trade-off between consolidation and growth-enhancing reforms (which would conversely require strengthened infrastructure and human capital).

Chart 5

Fiscal effort and share of govt. investment and education spending on total govt. spending, EU post 2010



Sources: elaborations on AMECO data.

All in all, what I want to flag is that, for a number of reasons, we should expect that a substitution relation between consolidation and reform will get stronger. What are the implications for EU economic surveillance?

The SGP rules are endowed with clauses that permit to take such possible trade-off between fiscal discipline and reforms into account. The application of these clauses however poses a number of challenges. First, they are conceived for “bad times”. Second, problems arise in assessing the implementation of reform plans ex-post.

More generally, even granting some leeway to accommodate trade-offs between consolidation and reforms, there is no guarantee that governments will choose to implement growth enhancing policies. Put in other words, the “discount rates” of governments cannot be imposed by Brussels. Governments are not bound by the EU fiscal rules to choose policies that strengthen the growth potential and improve public finances over the long term.

This calls for strengthening the incentives for governments to be forward looking and invest in policies that improve sustainability and growth over the longer term. In this respect, EU surveillance can become more effective by focusing on key reforms with EA and EU value added while ensuring implementation. The EU budget could also contribute to provide positive incentives to costly reforms by means of an effective application of conditionalities based on reform delivery.

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The impact of the cyclical downturn on long-term growth: Human capital, political economy, and non-performing loans

By Sergei Guriev[149]

Abstract

As Europe emerges from the Great Recession and the subsequent sovereign debt crisis, it has to make sure that the costs of the protracted recession are temporary and that there is no adverse impact on long-term growth. I discuss three channels through which the cycle may hurt potential growth: (i) human capital, (ii) the rise of populism, and (iii) non-performing loans. I also discuss policy responses to mitigate these risks.

1 Cycle and growth

Conventional economics textbooks draw a distinction between the macroeconomics of business cycles and the macroeconomics of long-term growth: the short-term volatility around the long-term GDP trend is assumed to be unrelated to the challenges of raising the growth rate of potential GDP. In reality, however, cycles and growth are not independent. If a recession persists for too long and if its effects are not mitigated, potential growth may be affected. In this case, countercyclical policies have both short-term and long-term implications.

Ball (2014) estimates the permanent loss of output in 23 OECD countries due to the Great Recession at about 8 percent of their GDP. What are the mechanisms through which cycles can affect long-term growth? Historically, the literature focused on the employment channel. If a recession lasts for too long and a large part of the labour force is unemployed or underemployed, it results in a higher natural unemployment rate and/or a lower labour force participation rate. In either case, this decreases the productive capacity of the economy (Blanchard and Summers (1986), Ball (2009)).

The second channel is related to political economy. If a recession affects the living standards of large parts of society, and if its distributional impacts are perceived as

[149] Chief Economist, European Bank for Reconstruction and Development. I would like to thank my colleagues Cevat Aksoy, Michelle Brock, Ralph de Haas, Martin Hoflmayr, and Alexander Plekhanov for carrying out the analysis presented in this article.

unfair, this may result in the rise of populist politicians who reject pro-growth policies and therefore reduce growth rates of the economy.

Finally, there is a banks' balance sheet channel. Financial crises normally result in the accumulation of non-performing loans. If these are not resolved, they continue to burden banks' balance sheets and undermine the growth of industries that rely on external finance.

In what follows, I will discuss these three channels in the context of the current situation in the euro area and the policy responses needed to mitigate the risk that the recent recession will leave a permanent economic impact.[150]

2 Unemployment and human capital

This channel has been studied relatively well. From the seminal "unemployment hysteresis" paper by Blanchard and Summers (1986) to the study of the recent European crisis by Gali (2015), the literature has identified the long-term implications of large increases in unemployment. Gali (2015) shows that the evidence from the recent recession in the euro area is indeed consistent with the unemployment hysteresis hypothesis.

Blanchard and Summers (1986) explain unemployment hysteresis by the impact of recession on employer-employee bargaining and the insider-outsider relationship. They de-emphasize the explanation related to declining employability of the long-term unemployed. On the other hand, Ball (2009) prefers the latter explanation. Those who stay out of work for too long fall behind their employed peers in terms of human capital and therefore face lower probability of finding a job in the future; many of these individuals stop searching for work and leave the labour force. This explanation is also consistent with happiness research. In individual-level regressions, unemployment has a large negative impact on self-reported life satisfaction – controlling for socio-demographic characteristics and even controlling for income (see e.g. EBRD (2016a, Chapter 2)). The effect of unemployment on subjective well-being goes beyond the associated decline in income – exactly because losing a job also undermines future welfare through reduced career opportunities.

Even though the euro area's economies have embarked on a recovery trajectory and the unemployment rate in the euro area is almost back to pre-crisis levels, this issue is still not fully resolved. First, there is substantial heterogeneity in terms of unemployment levels across European countries. In 2017 unemployment in Greece is still above 20 percent (and has been above 20 percent since 2012!), in Spain – only slightly below 20 percent, in Cyprus, Italy, and Portugal – at 11 percent. At the same time, unemployment in Germany stands at 4 percent – half of its 2007 level and half of the average unemployment rate in the euro area. Second, the crisis has

[150] While there may be other channels (see Ball (2014) for a discussion) I focus on these three as they seem to be most relevant for the current situation in the euro area.

resulted in the growth of *underemployment* (workers working fewer hours than they would like to) and an increase in the number of workers who are only marginally attached to the labour force (discouraged workers and those seeking work but not available for hiring). ECB (2017) shows that if these categories are added to the unemployment rate defined in the conventional way (the "U3" definition), the resulting measure ("U6") stands at 18 percent – a much higher level than in 2007 (14 percent).

The policy responses to the unemployment hysteresis problem are well known: active labour market policies and labour market reforms. The euro area includes several countries (mostly in Northern Europe) that have carried out such reforms and successfully lowered unemployment. Their example shows that such reforms can and should be implemented.

Europe should also promote labour mobility (in particular, through creating a common market for services and portability of social benefits and pensions). This is especially important given the high heterogeneity of labour market conditions both within and especially between European countries.

3 Political economy of populism

The second channel through which the crisis may affect economic growth is related to the rise in populism. In Algan et al. (2017), we study the relationship between the recession and the increase in populist votes in 200 European subnational regions (at the NUTS-2 level). As a proxy for the extent of the economic shock, we consider the change in regional unemployment before and after the Great Recession. In order to identify causal effects, we instrument the change in unemployment by the pre-existing structure of the regional economy. We find a substantial effect: a five percentage point change in unemployment raises the vote for populist parties by ten percentage points. We also study the change in attitudes (using the European Social Survey data) and find that the increase in unemployment has a major negative impact on trust in national and European political institutions. In contrast, higher unemployment has no effect on generalised social trust (trust in people) or trust in police.

We also study the specific case of Brexit where we analyse the evolution of unemployment in the UK's 379 electoral districts. While *average* unemployment in the UK is only five percent (below the pre-crisis level), the *median* British district has an unemployment rate that is two percentage points higher than before the crisis. Not surprisingly, our analysis shows that it is precisely the districts with a higher increase in unemployment that were more likely to vote for Brexit in 2016.

Another important factor explaining anti-establishment attitudes is the public's perception of unfairness. If voters believe that they are in the same boat with the elites and that the costs of recessions are shared in a fair way, a crisis does not have to result in the rise of populism. In the Baltic states, major budget cuts during the crisis have not brought populists to power. In Estonia and Latvia, the voters have actually re-elected the austerity governments.

On the other hand, if voters perceive there to be an unequal and unfair distribution of the burden of the crisis, they are more likely to rise against the establishment. In order to understand the distributional impact of the crisis, we follow Milanovic's "elephant curve" approach. Milanovic (2016) uses income data from household surveys to construct the evolution of global income distribution. His "elephant curve" shows the cumulative growth of income as a function of percentile in the global income distribution.[151] In the EBRD (2016a, Chapter 1) we use his approach to analyse the distributional impact of the transition from plan to market (both the first years of reforms and the whole 1989-2016 period). We find that in most transition countries the recession following the beginning of market reforms was highly skewed against the bottom 70 or 80 percent of the population – and similar results hold for the whole transition period (where only the top 20-30 percent have seen income growth above their country's *average* income growth). Not surprisingly, in many of these countries (and especially in those with the highest increase in inequality) the support for the reforms decreased substantially. Despite the hardship experienced under the planning system, in many post-communist countries only a minority supports market reforms today.

We have also conducted an analysis of the distributional impact of the Great Recession. Chart 1 shows that in Cyprus, Greece, Hungary, Italy, and Spain, the "recession tax" was highly regressive: the lower income deciles experienced greater income losses during the Great Recession. In Portugal, the lowest two deciles suffered especially badly while the top eight deciles shared the burden relatively equally – and in a progressive way. We do not present the graphs for the other euro area countries; there the recession's costs were mostly borne by the better-off – which is of course not surprising given that the recession normally results in redistribution and the decline in asset prices.

In EBRD (2016a, Chapter 3) we also show that it is not inequality per se but the *unfair* component of inequality that drives the rejection of the market system. We distinguish between two components of inequality: inequality of opportunity (the part that can be explained by exogenous circumstances – parental background, gender, place of birth, ethnicity and race) and the residual (apparently driven by effort and luck). The latter can be thought of as the "fair" component of inequality. When we include both "fair" and "unfair" inequality in the regression for the support for the market economy we see that the unfair inequality (inequality of opportunity) is negatively correlated with the support for markets while the fair inequality is positively correlated with the support for market reforms.[152] In these regressions (Table 1), we control for income and other individual characteristics; our results on

[151] Milanovic shows that the 1988-2008 period was especially beneficial for the global top 1 percent (the raised trunk of the elephant) and for the global middle class of Chinese and Indians (the top of the head of the elephant) and even for the bottom 10 percent (the elephant's tail). However, the second decile of global income distribution (the lower middle class in developed countries) has seen no real income growth in those two decades.

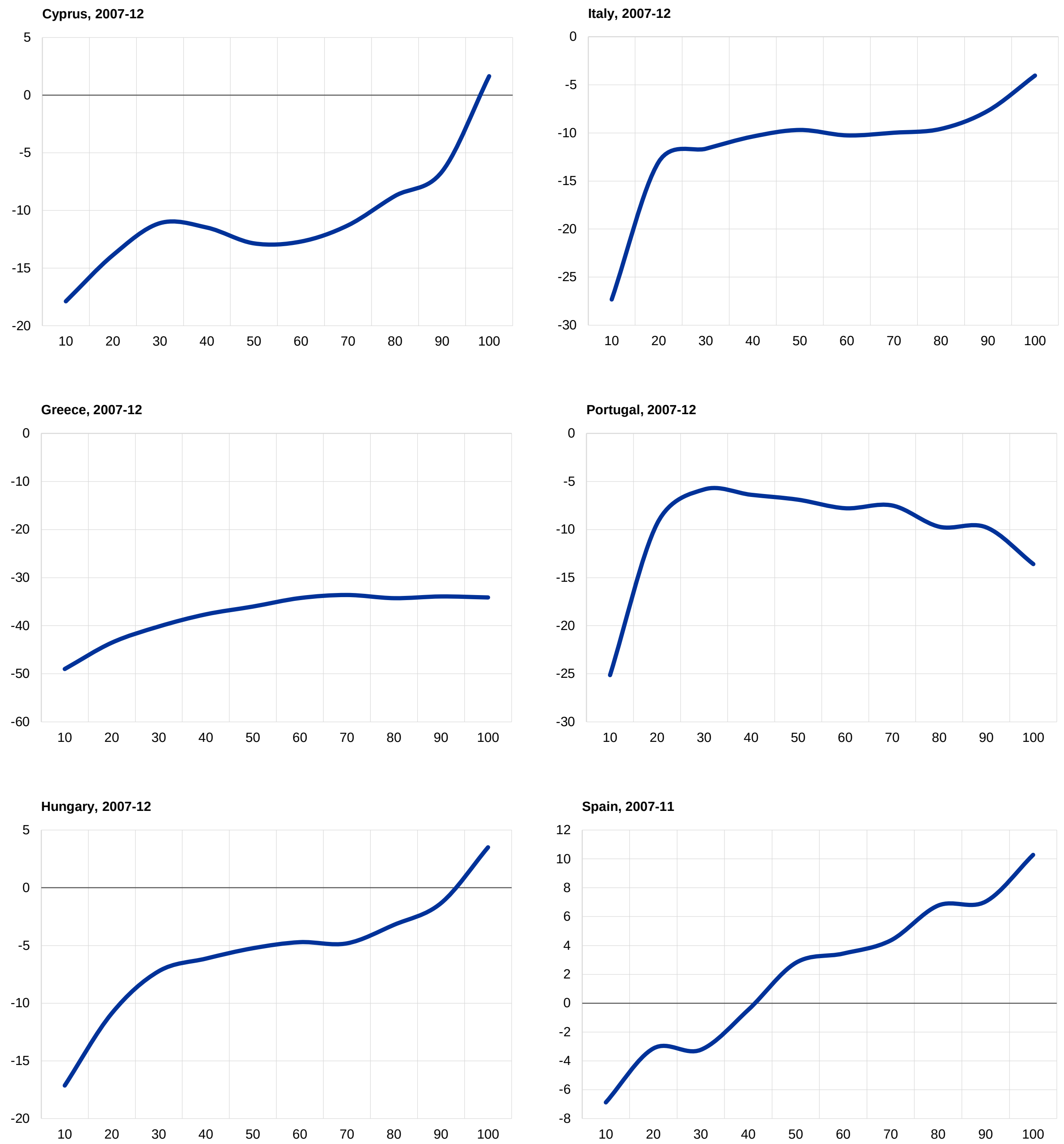
[152] This is broadly consistent with Starmans et al. (2017), who show that people prefer fair inequality to unfair equality.

the role of fair and unfair components of inequality are therefore not driven by the households' own material circumstances. In some regressions we also control for the household's subjective assessment of its position in the country's income distribution; the results do not change.

Chart 1

Cumulative income growth during the Great Recession as a function of decile of income distribution

(vertical axis: cumulative income growth in percentage points; horizontal axis: decile of income distribution, 10 is the poorest decile, 100 is the richest decile.)



Source: Povcalnet, see EBRD (2016, Chapter 1) for the methodology.

Table 1

Support for markets as a function of “fair” and “unfair” income inequality

Income inequality is split into the “unfair” component (inequality of opportunity: the part of income inequality explained by exogenous circumstances such as parental background, gender, place of birth etc.) and the “fair component (the residual, i.e. the part of income inequality explained by luck and effort).

	Linear probability model		Logit model	
“Unfair” income inequality	-1.093*	-1.012*	-4.508*	-4.169*
	(0.480)	(0.473)	(2.112)	(2.085)
“Fair” income inequality	1.046**	1.064**	4.424**	4.516**
	(0.354)	(0.356)	(1.587)	(1.600)
Perception of relative economic wellbeing		0.017**		0.077***
		(0.005)		(0.022)
Income decile	0.010***	0.008**	0.042***	0.035**
	(0.003)	(0.002)	(0.011)	(0.011)
Observations	12,258	12,185	12,258	12,185

Sources: Life in Transition Survey III, World Economic Outlook, World Development Indicators and authors’ calculations.
Notes: Dependent variable: support for market economy. Perception of economic wellbeing is the self-perceived income decile (1 corresponds to the poorest decile). Income decile is the objective decile in the income distribution based on respondent’s income. Additional controls include gender, education level, age and life satisfaction, region dummies, inequality of opportunity with respect to jobs and education, country inflation, unemployment and per capita GDP. Standard errors are clustered at the country level and are shown in parentheses. *, **, and *** indicate statistical significance at the 10, 5 and 1 percent levels, respectively.

Finally, the rejection of the system may be driven by corruption. Table 2 shows that even controlling for the individual material well-being (income, unemployment etc.) the individuals who believe that corruption is on the rise are more likely to reject market economy and have lower trust in the government.

Table 2

Corruption, support for markets and trust in government

	Support markets	Trust in president	Trust in government	Trust in parliament
There is less corruption now than 4 years ago	0.0408***	0.178***	0.200***	0.194***
	(0.0139)	(0.016)	(0.017)	(0.020)
Unemployment	-0.0430***	-0.029*	-0.019	-0.012
	(0.0130)	(0.017)	(0.013)	(0.009)
Log income	0.0271***	0.025	0.007	-0.005
	(0.00666)	(0.016)	(0.012)	(0.007)
R-squared	0.26	0.38	0.39	0.40
Observations	14045	13544	13779	13636

Sources: Life in Transition Survey II (2010) and III (2016). Panel of 1489 primary sampling units (PSUs). See the description of the data set in EBRD (2016b).
Notes: Additional controls include country dummies, year dummies, PSU dummies and individual level characteristics. Robust standard errors clustered at the country level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Should the populist backlash be accepted? Rodrik (2017) discusses the history of populism and argues that its current vintage is very different from conventional macroeconomic populism (Dornbusch and Edwards (1991)). Instead of proposing non-sustainable monetary or fiscal policies, the new populists reject competition and globalisation. It is still too early to judge how far the new populists can go when (and if) they win the elections but it is certainly clear that creating barriers to competition can only result in crony capitalism and lower economic growth.

Rodrik (2017) discusses potential solutions. He compares US and European systems of social support and argues that the European solution is preferable.

Instead of constructing special redistribution programs for the losers from trade, the European social compact includes generous social safety nets for the unemployed. European firms have accepted the high costs of funding such social programs; therefore there is a lower likelihood of populist backlash.

While this argument is correct in relative terms (comparing the US and Europe), there is still a high life-time cost of long-term unemployment (as discussed above). This is why it is not enough to support the unemployed with welfare benefits and training. The optimal policy response should involve conventional and non-conventional counter-cyclical aggregate demand policies to reduce the increase in unemployment and under-employment during the recession.

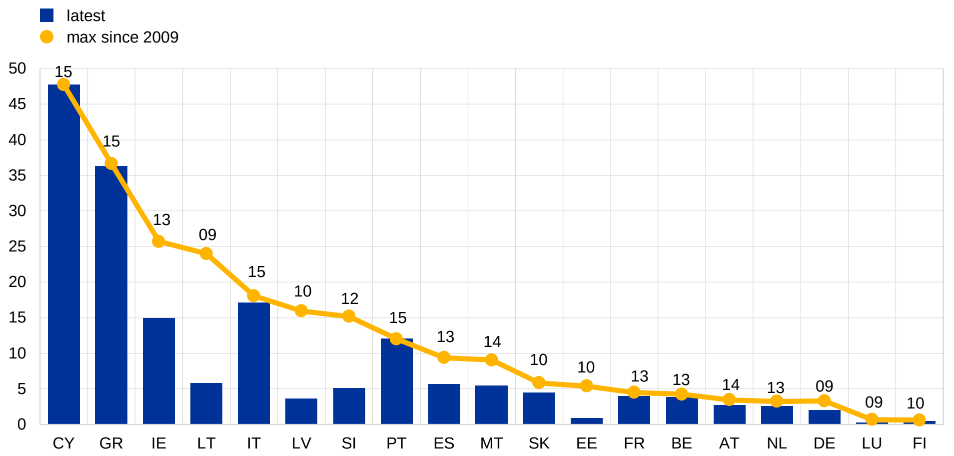
Also, the governance of the crisis response matters. Anti-corruption measures, transparency, and assuring a level playing field help to increase the confidence in institutions and reduce the chances of populists' success.

4 Non-performing loans

The Great Recession followed a credit boom; the subsequent bust left banks saddled with a large stock of non-performing loans (NPLs). The slow post-crisis recovery and the lack of decisive efforts to handle the NPL problem have resulted in continuing high levels of NPLs. In some countries the NPL rates (stock of NPLs as the share of total loans) is still in the double-digit range (Chart 2); in Cyprus and Greece, they are above 35 percent.

Chart 2

Non-performing loans (as % total loans) in selected euro area countries



Source: see Balgova et al. (2016).
Notes: the numbers on top of the dots indicate the year of the highest value of the NPL rates.

Economic literature has shown that the non-performing loans are a drag on growth. Caballero, Hoshi, and Kashyap (2008) analyse the Japanese stagnation of 1990s and 2000s and show that rolling over ("evergreening") loans to the non-profitable ("zombie") firms slows down creative destruction. Capital and labour remain stuck in the zombie firms, which reduces productivity growth in non-zombie firms.

Using the data on NPLs for the 1997-2014 period, Balgova, Nies, and Plekhanov (2016) study the NPL resolution experience in 100 countries. They classify these historical episodes into three types: (i) growing out of NPLs; (ii) resolving actively; (iii) procrastinating. In the first scenario, the NPL stock does not decrease but growth of GDP and new lending results in lower NPL rates. In the second scenario, the countries do reduce the nominal stock of NPLs. In the third scenario, there is neither a reduction in NPLs nor a pick-up in economic activity – so NPL rates remain high. In order to study the impact of NPL resolution on growth, the authors match economies with active and passive handling of the NPLs based on observable characteristics. Their analysis shows that the active NPL resolution increases GDP growth rates by about 2 percentage points a year for 4 years.

The significant impact of NPL reduction on growth implies the need for policies that can reduce the burden of the NPL. Given the high levels of sovereign and bank leverage in Europe, this work requires development of equity markets – including building the Capital Markets Union.

5 Concluding remarks

The protracted recession and the slow recovery create the risk of "the output gap closing the wrong way" – instead of GDP catching up to the long-term trend after the recession, the trend may get adjusted down towards the current GDP trajectory. There are at least three reasons to believe that these risks are important in today's euro area. First, there is a risk of reduced employability of the long-term unemployed. Second, there is the risk of the rise of populism and associated anti-market policies. Finally, the accumulated stock of bad loans slows down productive reallocation and therefore also reduces growth rates.

The solutions to these problems are well-known: labour market reforms, active labour market policies and retraining, social safety nets, policies supporting labour mobility, active resolution of NPLs and the development of equity markets.

The problem with the latter is that Europe has traditionally relied on banks. The good news is that there are new arguments in favour of developing capital markets. De Haas and Popov (2017) study a panel of 73 countries and 18 industries for 1974-2013 and find that the impact of financial development on industrial pollution depends on the structure of the country's financial system. Growing bank lending results in higher pollution while deeper equity markets help to reduce. This is intuitive. Banks lend against collateral – and thus are biased towards mature technologies. Green investment is longer-term oriented and has higher uncertainty of the value of the collateral – thus requiring equity rather than debt finance. Policies that promote faster long-term economic growth are therefore also likely to support the much-needed transition to the green economy.

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Increasing public support for research and development in the U.S.

By Simon Johnson[153]

America used to lead the world in developing technology – and in building middle class prosperity. After World War II, America built the cars, planes, medicines, and appliances that consumers around the globe wanted to buy. The underlying basis for this dynamic economy was technological innovation, driven by a major publicly-funded innovation push in the post-war period. From 1940 to 1965, federally government-funded research and development as a share of the economy rose twenty-fold.

American technological leadership brought with it growth of 3% or more per year. This rapid economic expansion created millions of high paying jobs, not just in scientific discovery, but also in manufacturing and the commercialization of ideas. These jobs spread prosperity across the country and created a successful middle class.

This era of technological leadership is over. The U.S. is no longer the leader in many of the technologies that define the modern era, from semiconductors to clean energy technology.

A primary culprit is the retreat in our government's commitment to funding science research over the past 50 years. The American private sector invests, but not in basic science. The result is a private sector focus on how best to *replace* jobs with robots – as in the race between Google, Uber, and others to invent the self-driving car. The companies working on how best to *make* the robots are in Japan and China, not the U.S.

Our failure of technological leadership has directly resulted in a slower economy, where we struggle to reach 2 percent annual growth. This deceleration has profound implications: less job creation, lower incomes for millions of Americans, and many parts of the country feeling left behind.

Frustration over the growth slowdown is entirely justified, and contributes to the election of backward-looking politicians like Donald Trump who promise a return to high paying, low tech jobs that are gone forever. And neither political party has been able to promote a comprehensive pro-growth agenda to act as an alternative.

To really improve the performance of the American economy – and to raise incomes across the board – we need to invest heavily in the underlying science of computing, robotics, human health, and clean energy.

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The good news is that the preconditions for a new growth engine are already in place. We have the world's leading universities, the best conditions for starting new business, and plenty of capital willing to take risks. What we need is a big new public and private sector push to encourage and support the creation of ideas that can be converted into technology. And to make this push effective, we should support it with a major expansion in science education across all ages, with the goal of producing – and employing – many more university graduates with technical skills.

The Research Triangle Park in North Carolina is a great model for how the public and private sectors can work together to create innovative hubs where previously there were only fields. There have been positive results also in places as different as Alabama, Florida, and Arizona. But we need more than a few scattered success stories. Every state should have a chance to build its own job-creating innovation hub.

1 What Went Wrong

America's growth slowdown has a simple cause. In World War II and during the Cold War, we built the most powerful engine of growth that the world has ever seen: the application of scientific research to practical problems. The technologies that this created were transformative – resulting in new products, new companies, and an almost insatiable demand for American goods and services around the world.

The industries created – based directly on public investments in science – included aerospace, digital computers, satellites, pharmaceuticals, and telecommunications. And, of course, the internet. Private companies were encouraged to utilize and build on these technologies. This is how we got almost everything that is essential to modern life, including mobile phones, laptop computers, and all the software that runs the infrastructure of modern life.

But we failed to maintain the engine. From the 1960s onward, we curtailed our investments in basic scientific research. Consequently, the stock of knowledge has increased more slowly than it would have otherwise – over time, this has meant lower growth and less job creation in research, commercialization, and manufacturing. The American corporate sector now invests less, relative to the size of the economy, than at almost any time in the post-war period – in part because there are fewer compelling new technologies that need to be adopted.

2 Where Are We Now?

From the 1980s, improvements in digital computing created unprecedented opportunities for automation across a wide range of sectors, reducing the need for workers with only a high school education. Dramatically cheaper communications and a significant decline in the cost of physically moving goods meant many manufacturing tasks could readily be shifted to countries with lower wages.

This process of job destruction is a normal part of any market economy, and existed also during the boom years of the 1950s and 1960s. What changed was that, as part of the broad turn against a proactive role for government, American politicians deliberately slowed down the process of invention that creates new middle class jobs.

We see the impact in current high levels of inequality and political polarization across regions. In large cities on the east and west coasts, innovation dominates economic activity, high paying jobs are created, and many people feel optimistic. But in most of the rest of the country, there are fewer good jobs, wages face downward pressure, and there is much greater anxiety about the future – with good reason. Under the policies of this administration, these inequities will likely only become more extreme.

3 Restarting the Engine

The obvious answer is to increase the amount of public funding provided to basic scientific research. State and local governments should take the lead in building new clusters of technology activity, based on local expertise and existing specializations. The federal government should back these hubs as a co-investor, but only when suitably pro-private sector growth conditions are put in place – including appropriate land use and development rules.

The private sector will jump on this bandwagon. When the public sector invests, this creates opportunities for construction, commercial and residential. Innovative hubs will offer advantageous terms to early tenants. Locating in creative places is the best way to ensure you can hire smart people and make good use of their ideas. And the process of creating strong infrastructure for innovation will create jobs for people with a broad range of skills.