CHAPTER 3

Economic and social fundamentals: from productivity to fair and sustainable growth

1. Introduction ([156])

Current economic growth may not be sustainable over the long-term. Chapter 2 showed that the concepts of growth and welfare need to incorporate a number of dimensions in order for growth to be sustainable over the long term. High economic growth tends being accompanied by environmental problems, suggesting that there may be a trade-off between our economy delivering welfare gains and staying within the limits set by planetary boundaries ([157]). Indeed, the economy consumes resources to achieve a certain level of income. The scarcity of these resources could cause bottlenecks in the future while the consequences of not respecting the planetary boundaries may include social costs in the form of environmental harm and climate change (see Chapter 5). ([158])

The use of natural resources is not the only challenge to sustainable growth. Labour supply, too, is becoming scarcer due to demographic developments and the shrinkage of the EU's working-age population that started in 2010 and is set to continue over the next few decades. ([159]) Moreover, growth may not be socially sustainable, for instance, if it excludes workers from decent wages, decent social protection standards or wider career opportunities. Finally, GDP growth may not be sustainable if it relies on obsolete technologies and if it focuses too little on innovation and raising competitiveness in the future (see Chapter 4).

Quality growth comes from efficient use of scarce resources. The constraints mentioned above are highly relevant to the quality dimension of economic growth. Many of them may not be sufficiently captured by the standard economic accounting framework, with GDP as the traditional measure of economic activity and welfare. ([160]) Yet, this standard framework still allows for analysing problems that arise from the inefficient use of resources in generating production. Economic growth depends on the possibility of increasing the input of labour or other resources in production. But it also comes from using these factors more efficiently in production. A given quantity of productive factors can be used more efficiently in two ways: ([161])

– Productive factors are re-allocated to tasks where they can add more to production so that their potential is not wasted (allocative efficiency).

– The quality of the factors increases, e.g. through improved work organisation, smoother procedures,

([156]) This chapter was written by Jörg Peschner, Giuseppe Piroli (DG Employment, Social Affairs and Inclusion) and D'Artis Kancs (DG Joint Research Centre).

([157]) European Political Strategy Centre (2019), p. 4

([158]) Human activities have significantly changed the climate and increased the magnitude of extreme weather events such as heat waves, heavy precipitation and droughts. Climate-related extremes will affect many European regions in the future. "The total reported economic losses caused by climate-related extremes in the EEA member countries over the period 1980–2013 were almost EUR 400 billion (2013 value) " (European Environmental Agency, 2017, p. 195.

([159]) ESDE 2017 (Chapter 2) has shown that the pressure to achieve productivity growth in the future will strongly increase as working-age population declines.

([160]) The 'Beyond GDP' initiative seeks alternative measures for 'more inclusive environmental and social aspects of progress'. See http://ec.europa.eu/environment/beyond_gdp/index_en.html

([161]) Nicodème and Sauner-Leroy (2004), p. 3.

more use of innovative capital, faster diffusion of knowledge or better trained labour (productive/dynamic efficiency). ([162])

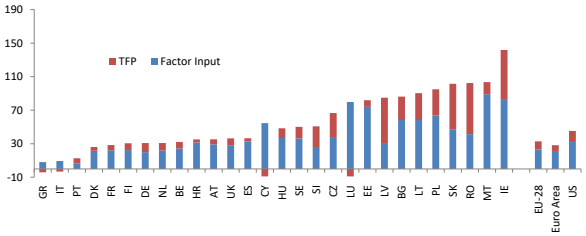
Total Factor Productivity is an indicator of qualitative aspects of growth. While the concepts of labour and capital productivity relate a firm's output to labour or capital input, Total Factor Productivity (TFP) accounts for the specific part of output expansion that is *not* due to an increase of factor input. TFP can thus be interpreted as a measure of the qualitative part of economic growth, i.e. the extent to which a given range of productive factors are used efficiently. TFP can therefore be considered as an indicator of a firm's innovative capacity and its degree of resource efficiency in production. ([163]) *Annex 1* provides a technical explanation of the concept of TFP.

Many countries have considerable potential for higher growth through higher efficiency. *Chart 3.1* shows that roughly half of the EU's cumulative growth in potential GDP since the turn of the century is due to TFP growth. However, the EU's TFP growth has been lower than in the US in the last few decades. There is also little evidence that the EU's TFP levels catch up to the US in recent years. ([164]) Authors attribute this finding to problems in the market services sector in particular: market imperfections (low competition) as a result of non-completion of the single market and a failure effectively to tap into the potential of ICT technologies. ([165]) Within the EU, there is a wide variation across Member States. For a number of Member States, the overall GDP growth performance has been modest. These countries have the potential to improve their GDP growth rates significantly through higher TFP growth rates.

Chart 3.1

Roughly one third of the EU's potential GDP growth comes from growth in TFP

Growth of potential GDP between 2001 to 2020 and its components, percent



Note: 2019 and 2020: Commission 2019 Spring Forecast

Source: Commission Services' AMECO database

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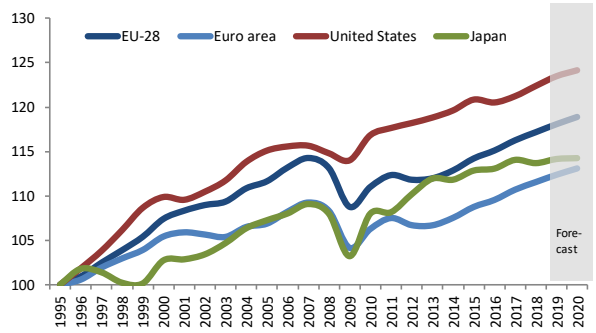
Chart 3.2

TFP grows more slowly than before the crisis

TFP between 1995 and 2020, 1995=100



Note: Includes the Commission's Spring Forecast

Source: Commission services AMECO database

Click here to download chart.

However, TFP growth slowed down worldwide during the crisis. During the crisis productivity declined sharply. In the EU, the main reason was the hoarding of labour that took place as short-term work arrangements were used to smooth out the economic downturn. ([166]) Despite the economic recovery since 2013, the rate of growth of TFP is not back up to its pre-crisis level (*Chart 3.2*). ([167])

This chapter is devoted to assessing recent developments in productivity growth with a particular focus on TFP. It looks at convergence over time and across regions and explores the determinants of TFP, making use of regional growth accounting data and firm-level information.

2. PRODUCTIVITY IN THE REGIONS: DEVELOPMENT AND DRIVERS

2.1. Strong differences across regions

TFP growth comes from higher efficiency. According to its conventional residual calculation, TFP-growth is the part of output growth that is not due to increased input of the productive factors of labour and

([162]) Improving the quality of capital or the skills of workers will increase workers' productivity. Workers will then, on average, add more value to production. These improvements can be attributed to labour input and the efficiency gain will be treated as additional labour input (referred to as 'labour augmented progress' in the literature). By contrast, pure labour input can be separated from these efficient gains and thus considered only in terms of the number of hours worked. In this case the efficiency gains will appear in the accounts of total factor productivity. The latter is the approach taken in the following unless otherwise indicated.

([163]) For example, see Comin (2010), p. 260. The link between productivity and innovation is complex however (Hall, 2011).

([164]) Thum-Thysen and Raciborski (2017) explored euro area TFP convergence with the US.

([165]) Timmer et al (2010), van Ark (2014).

([166]) People stayed employed but did not actively work. See Arpaia et al (2010), p. 12.

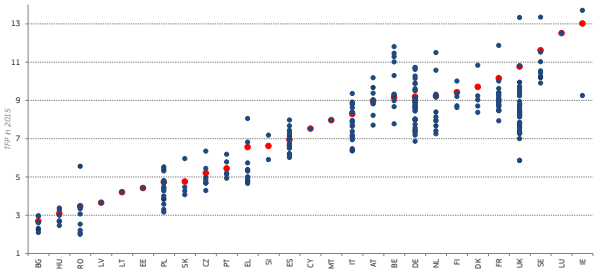
([167]) See Majumdar (2017). https://www2.deloitte.com/insights/us/en/economy/behind-the-numbers/decoding-declining-stagnant-productivity-growth.html

capital (see the technical details in *Annex 1*). The following analysis takes into account information about 274 European regions at NUTS-2 territorial level ([168]) for the period between 1995 and 2015. ([169]) *Chart 3.3* outlines major differences in current regional TFP performances in 2015: a number of peripheral regions, especially in Eastern Europe, are still lagging significantly behind. There is also wide variation within countries.

Chart 3.3

TFP: Eastern European regions lag behind. Strong variation within countries

Total factor productivity per NUTS-2 region



Note: Each blue dot represents one region. Red dots represent averages per country (weighted by regional gross value added). Data for Croatia not available. Inner London is not reported to improve visualisation.

Source: Commission services

Click here to download chart.

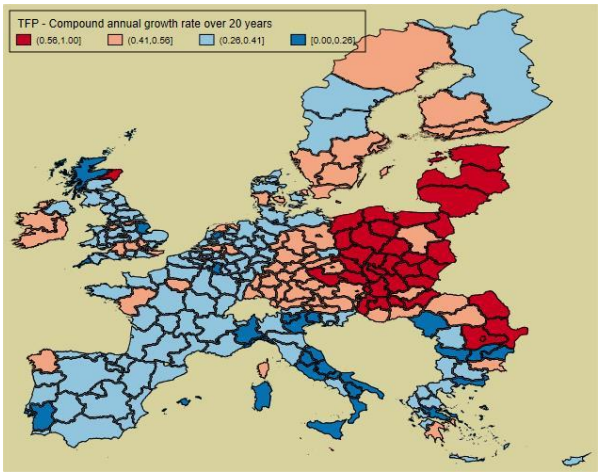
2.2. Significant, yet uneven and decelerating growth of TFP within the EU

Eastern Europe has grown comparably fast in terms of TFP. *Chart 3.4* reveals that the last 20 years have seen Eastern Europe grow relatively fast. The strong TFP growth rates boosted convergence in this region especially between the 1990s and 2008. ([170])

Chart 3.4

Faster TFP growth in Eastern Europe regions during the last two decades supported convergence

Growth of TFP from 1995 to 2015 (standardised values)



Note: Index (standardised values). Data for Croatia not available.

Source: Commission services

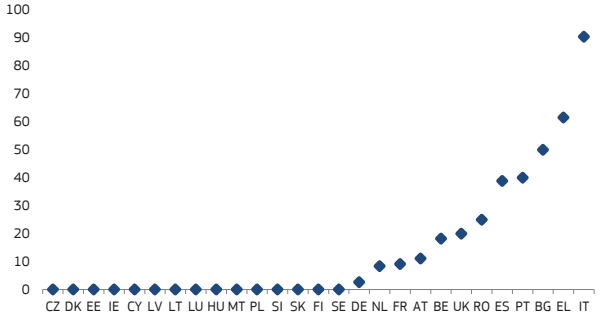
Click here to download chart.

In many Southern European regions TFP performance has been low. This is the case for Italy in particular. 19 out of 21 Italian NUTS-2 regions appear to have shown negative TFP growth. ([171]) The Commission's 2019 Country Report on Italy sees structural obstacles as the main reason for low TFP growth, noting that 'they hamper an efficient allocation of production factors across the economy' and a faster diffusion of new technologies'. ([172])

Chart 3.5

The South of Europe is over-represented amongst regions with negative TFP growth

Percentage of NUTS-2 regions where TFP growth between 1995 and 2015 was negative.



Source: Commission services

Click here to download chart.

While TFP growth has slowed down, regions tend to converge. The overall increase in TFP between 1995 and 2015 was around 0.5% per year, while in the first ten years of the period (1995 to 2005) it was significantly higher (0.75%) ([173]) However, despite slowing TFP growth there has been regional convergence of TFP throughout the entire period. *Chart 3.6* shows the link between regions' starting level of

([168]) Regions are categorised according to the Nomenclature of Territorial Units for Statistics (NUTS). NUTS-2 stands for 'basic regions for the application of regional policies'. See Eurostat at https://ec.europa.eu/eurostat/web/nuts/background. Croatian regions and a number of outermost Spanish, French and Portuguese regions are excluded from the analysis for technical reasons.

([169]) Data on regional output and labour came from a regional database built by Cambridge Econometrics and publicly available on the website of the Commission's Joint Research Centre. The authors are grateful to Ben Gardiner (director at Cambridge Econometrics), who provided the time series of regional capital stocks for the period up to 2008 (see Gardiner et al, 2011). These time series were extended by using data on regional gross fixed capital formation from Eurostat and national capital stocks from EU-KLEMS database, see http://www.euklems.net/. Main missing information, i.e. national capital stock for Belgium and Portugal, was filled using official national statistics.

([170]) International Monetary Fund (2016), p. 3.

([171]) Given the measurement errors included in the calculation of TFP and the small magnitude of some negative changes, however, the finding should be considered as evidence of no growth in TFP especially in the South of Europe.

([172]) European Commission, Country Report Italy 2019, p. 8.

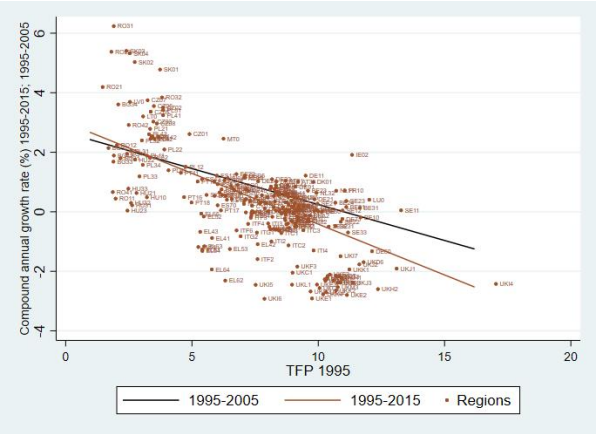
([173]) During the period 2005-2015 it was lower than 0.3%.

TFP in 1995 and their growth rate until 2005 and 2015, resp. In both periods the link is negative: regions where productivity levels were low at the beginning tended to experience faster TFP growth.

Chart 3.6

TFP: Lagging regions tend to converge

TFP: 1995 levels (horizontal axis) and changes in percent (vertical)



Note: Levels: 1995 and changes: 1995-2015. The curve has a negative slope. A lower level of TFP would imply higher TFP growth. Lagging regions thus tend to catch up (convergence).

Source: Commission services

Click here to download chart.

2.3. The drivers of regional TFP development

Absorbing benchmark technology is key for regions to catch up. The further a region lags behind the technological frontier, the higher its TPF growth potential may be, provided it is able to adopt the benchmark technology. Understanding the drivers behind the processes of convergence and technological diffusion is of paramount importance. One argument supporting the hypothesis of convergence is that the differences that still exist between regions increase the potential of low-performance locations to catch up (convergence thesis). A study on the convergence of TFP across German states (*Länder*) finds a significant role for what they call the 'technological frontier' for a region's TFP performance. The frontier is here a certain region considered as a technology benchmark. The capacity of a lagging region to absorb cutting-edge technology which has been developed in a benchmark region helps the lagging region to catch up (i.e. reduce the distance to the benchmark) faster. ([174])

Human capital and R&D are key drivers of TFP performance. Circumstances in which the TFP of lagging regions converges towards the technology frontier have been extensively investigated in the literature. The main challenge for European regions' labour productivity growth is that regions are not making the most of their human capital and innovation potential. In addition, the level of knowledge resources ([175]) within a region is the key to benefiting from dissemination of technological knowledge external to the region. ([176]) Also, institutions seem to have a strong impact on a region's innovation potential and thus on its productivity growth. ([177])

The convergence thesis tested: a regression model. The analysis in this section tests examines these inter-relationships using a TFP-catch-up framework for European regions ([178]), for which a complete cross-regional database has been built covering the period 1995-2015.

A region's stock of human capital is proxied here by the average years of schooling in each region. Its 'absorptive capacity' is its ability to learn, or more accurately, its 'ability to identify, assimilate, and exploit knowledge from the environment'. ([179]) The model tests whether a region's absorptive capacity is a function of both the stock of human capital and R&D expenditure. ([180]) Both factors are thus seen as potential reasons for differences in the speed with which follower regions catch up with more developed regions that represent the technology frontier. *Annex 2* outlines the technical explanation of the model adopted.

([174]) Burda and Severgnini (2018). Earlier literature has identified this as the main "advantage of the latecomer." See, for instance, Mathews (2002).

([175]) Vogel (2013) finds R&D would facilitate the imitation of technologies from geographically close regions.

([176]) See also Thum-Thysen and Raciborski (2017) who find that "spill-overs stemming, for instance, from technology adoption or imitation and also by the global impact of the economic crisis" (p. 41) are important drivers of TFP-convergence of EU countries towards the US.

([177]) Rodríguez-Pose and Ganau (2018) support this view in a presentation given at ECFIN Annual Research Conference "The productivity challenge: Jobs and incomes in the dawning era of intelligent robots", Brussels, November 2018.

([178]) The model uses the approach of Benhabib and Spiegel (2005).

([179]) Cohen, W. M., Levinthal, D. A., Innovation and Learning: The two Phases of R&D, The Economic Journal, 99, September 1989, p. 569.

([180]) Eurostat regional data are used here.

Table 3.1

Human capital, R&D and the gap to the benchmark strongly determine TFP

Regression coefficients with TPF as dependent variable

Dependent variable: TFP growth	Model A1	Model A2	Model A3	Model B1	Model C1	Model D1
Human Capital	0.057***	0.016***	0.080***	0.070***	0.070***	0.016
Human Capital*gap	-0.030***	-0.028***	-0.031***	-0.035***	-0.033***	
R&D				0.003***	0.003***	0.005***
KSI					0.013***	0.01
Human Capital*R&D*gap						-0.011***
Constant	-0.093***		-0.146***	-0.122***	-0.128***	-0.037
Dummies countries			yes	yes	yes	yes
Dummies years			yes	yes	yes	yes
Observations	4172	4172	4172	4172	4172	4172
Regions	263	263	263	263	263	263

Note: 'Gap' is defined as a region's TFP divided by the TFP of the technological frontier. If the distance between the two is high, 'gap' will be low.

Source: Commission services

Click here to download table.

Well-educated workers and high research activity strongly favour TFP growth. The results of various model specifications are shown in *Table 3.1*. They can be summarised as follows: ([181])

- There is a strongly significant and positive link between human capital and TFP in all model specifications: Better-educated workers increase production efficiency.
- A region's high expenditure on R&D improves its TFP performance significantly.
- A high TFP gap vis-a-vis the benchmark region tends to trigger a region's TFP growth because "more" technology is available for being potentially absorbed. This finding broadly confirms the convergence thesis. However, the higher a region's TFP gap the more important become human capital and R&D for the process of absorbing benchmark technologies. Both research-orientation and the availability of qualified labour facilitate a region's capacity to absorb technology from other regions.
- Industrial specialisation ("Krugman Specialisation Index" ([182])) in certain products tends to increase TFP as learning effects may be stronger and help to improve efficiency in production.

Quality of institutions seems to favour TFP. For the years from 2010 to 2013 ([183]) data makes it possible to include a variable that captures the role of quality institutions in TFP development. Therefore, a new variable is introduced, which draws on the European Quality of Government Index (QoG) ([184]), as another factor explaining the growth in TFP. Based on perceptions, it is a proxy for the quality of institutions. The composite indicator calculated from survey data (using subjective information) has three main sub-components (i) absence of corruption, (ii) the strength of 'the rule of law' and (iii) 'government effectiveness, voice and accountability' as perceived by the respondents. ([185]) All of these indicators illustrate the extent to which people trust governmental institutions. The results are shown in *Table 3.2* and can be summarised as follows:

([181]) The main results are confirmed by the panel specifications of the model and by the analyses provided in Manca and Piroli (2011) for the period 1995-2005 in a spatial approach.

([182]) See Annex 2.

([183]) For 2010, the EQI contains 172 regions based on a survey that was answered by 34,000 citizen respondents. For 2013 the EQI has been expanded to 206 regions based on a survey that was answered by 85,000 citizen respondents, which is the largest sub-nationally-focused survey on QoG to date.

([184]) Comparative database provided by the Quality of Government (QoG) Institute at the University of Gothenburg; https://qog.pol.gu.se/data.

([185]) For further details see Charron, Dijkstra and Lapuente (2014).

Table 3.2
Quality institutions are crucial for productivity
Explaining TFP growth: the role of institutions

Dependent variable: TFP growth	Model A4	Model B2	Model C2	Model D2	Model E1	Model E2	Model E3
Human Capital	0.0807***	0.0938***	0.0838**	0.054	0.0803***	0.0752***	0.0719***
Human Capital*gap	-0.0230***	-0.0256***	-0.0262***		-0.0217***	-0.0234***	
R&D			0.0007	0.0028		0.0016	0.0056***
KSI			-0.0083	-0.0154			
Human Capital*R&D*gap				-0.0097**			-0.0158***
Quality of Government	0.0003***	0.0001	0.0001	0.0001			
Corruption					0.000	0.000	0.000
Rule of law					0.0003*	0.0003*	0.0002
Effectiveness, voice and accountability					0.0003*	0.0003*	0.0003*
Constant	0.0807***	0.0938***	0.0838**	0.054	0.0803***	0.0752***	0.0719***
Dummies countries		yes	yes	yes			
Dummies years		yes	yes	yes			
Observations	526	526	526	526	526	526	526
Regions	263	263	263	263	263	263	263

Note: 'Gap' is defined as a region's TFP divided by the TFP of the technological frontier. If the distance between the two is high, 'gap' will be low.
Source: Commission services
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– **People's trust in high-quality governmental services supports higher productivity.** The estimated impact of the overall QoG index on TFP is highly and positively significant. This finding had already emerged from the factor analysis in Chapter 2. It is also broadly confirmed by the literature. ([186])

– Though significantly correlated with each other, two of the three single sub-indices also tend to be significant in most model specifications: people's perception of the 'rule of law' and government 'effectiveness'.

([186]) For example, see Annoni and Catalina-Rubianes (2016).

2.4. Summary

– **TFP is driven by a region's capacity to innovate**: educated workers and a strong orientation towards research and development (R&D) clearly foster efficiency.

– **The convergence thesis is largely confirmed.** The further away from the benchmark, the higher a region's TFP growth tends to be. Yet a region's TFP growth potential depends on its capacity to absorb new technologies from technological benchmark-regions. The absorption capacity, in turn, is higher the better educated the region's workers and the higher its R&D expenditure.

– **Trust in the effectiveness of government institutions favours productivity.** This finding confirms the factor analysis in Chapter 2. Those countries where institutions generate trust and project efficiency tend to have significantly higher productivity.

3. Drivers of TFP: Analysis at firm level

Some firms are more productive than others. This chapter extends the analysis of TFP and its convergence but changes perspective: instead of regional differences, it looks at differences across firms.

The comprehensive CompNet firm-level-based dataset is used for this purpose. It is provided by the *Comp*etitiveness Research *Net*work founded by the European Central Bank and offers a wide range of productivity-related indicators constructed on the basis

of firm-level information for 18 EU countries. ([187]). A variety of specific variables depict a firm's innovative capacity, notably its total factor productivity (TFP), which can be interpreted as a measure of efficiency in production.

This section looks first at the TFP dynamics of firms with at least 20 employees ([188]), exploring whether the convergence thesis also holds at firm level. It then turns to the question of the characteristics of a firm that lead to higher (or lower) productivity.

3.1. Convergence at firm level

Convergence holds if a firm improves its efficiency in production over time so as to come closer to those firm(s) that represent the TFP benchmark. Using data from 2004 to 2015 this section looks at how firms' TFP performance changed over a period of four years and what the drivers of the change were. *Annex 3* provides a technical explanation of the regression model, while *Table 3.3* presents its results. They can be summarised as follows:

Table 3.3

There is considerable TFP convergence at firm level.

Regression coefficients, dependent variable: 4-year change of TFP of a given type of firm

	Coefficient	Std.Error	Sign.
Wage growth	.885	.000	.000
TFP distance to frontier	.397	.001	.000
Left-skewed distribution	.052	.003	.000
Crisis	-.042	.000	.000
Small Firm	-.023	.000	.000
Controlled for country	yes		
Controlled for macro-sector	yes		

Note: Data used: 1999-2016 (different data availability across countries)
TFP growth: log of TFP in t minus log of TFP in t-4; Wage growth: log of wages per worker in t minus log of wages per worker in t-4,
TFP distance from frontier: log of the difference between a firm type's TFP and the TFP of the benchmark firm (the latter being the firm at the 95% percentile of the TFP distribution)
Left-skewed distribution: dummy capturing whether the skewedness of the distribution in the firm-cluster is negative CRISIS: Dummy equal to one during the crisis years 2008-2013, zero otherwise.
Small Firm: Dummy equal to one if firm has less than 50 employees, zero otherwise.

Source: Commission services based on CompNet data

Click here to download table.

– **Faster-growing wages go hand-in-hand with higher TFP.** Wage growth correlates with TFP growth. This finding says little about the direction of causality. ([189]) Yet it signals that there might be a productivity dividend in wages. ([190]) In addition, as wages represent the price of human capital, they reflect the human capital dimension discussed in the previous section, pointing to the fact that appropriately priced human capital favours efficient production.

– **Firms that are further away from the TFP frontier improve TFP faster – if they survive**. For the purposes of the regression, the frontier firm can be seen as the technological benchmark. It is defined here as the one firm at the 95th percentile of the TFP distribution. In other words, 95% of firms in a sector ([191]) attain a TFP lower than this benchmark firm. The higher the distance between the frontier and the average TFP in that sector, the higher is the sector's TFP growth. Indeed, the least competitive firms either manage to catch up, or they need to leave the market. Convergence at firm level is therefore a result of market selection.

– **A presence of more firms with high TFP tends to trigger other firms' TFP growth potential.** If the TFP-distribution is 'left-skewed' this implies that there are relatively few firms with low TFP in the sector concerned while a relatively large number of firms attain high TFP. There are thus many benchmark firms from which other firms could learn. The scope for transferring knowledge from firm to firm is therefore higher.

– **Small firms stand a lower chance of increasing TFP.** This finding holds after controlling for the TFP distance to the frontier which captures a firm's relative competitiveness. However, the next section will show that there are means to overcome the size-disadvantage: those include exposure to international competition through participation in global value chains, removal of labour and product market imperfections, and access to credit.

– **The crisis has reduced TFP growth.** Data from 2004 to 2015 was used. During the years 2008 to 2013 firms' TFP growth was significantly lower.

3.2. Drivers of TFP-levels: a base model

The following analysis looks at differences between the *levels* of TFP across firms. It measures the determinants of a firm's innovative capability. First, it orders all firms in the dataset with respect to their TFP performance, building ten equal-sized deciles of the sample. It then performs an ordinal logistic regression to calculate a firm's chances (odds) of being in a higher TFP decile ([192]), depending on an array of explanatory variables.

([187]) The 6th Vintage CompNet Dataset includes firm-level information from Belgium, Croatia, Czechia, Denmark, Finland, France, Germany, Hungary, Italy, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden, see CompNet (2018), p. 6.

([188]) This is done in order to avoid a number of technical problems at lower firm level and have a more homogeneous sample of countries, see CompNet (2018), p. 5.

([189]) There could be reversed causality: wage growth following productivity growth.

([190]) The Efficiency Wage Theories suggest that wages may well drive productivity. For example, firms may pay higher wages than productivity would justify in order to increase work satisfaction and to remain attractive for qualified workers. (Katz, 1986). Higher TFP would result.

([191]) The CompNet file used here looks at firms of a given sector, year and size-class.

([192]) The ratio of odds relates cumulative probabilities to their counter-probabilities. For example, it can be odds for a firm of being in deciles 7-10, relative to being in deciles 1-6; or: in decile 8-10, relative to 1-7. See, for example, Norušis (2012), esp. p. 75-76.

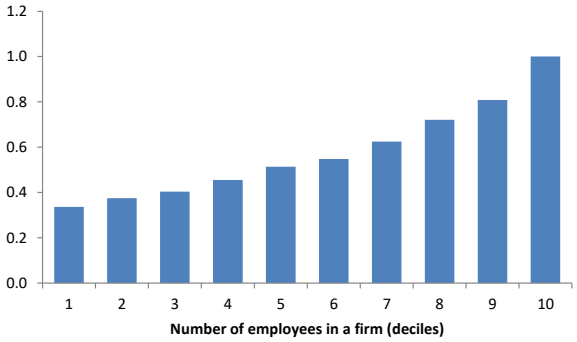
The results of a series of ordinal logistic regressions are presented in a table in *Annex 5.* The sections below give a non-technical overview. The variables included in the base model allow the following conclusions to be drawn: ([193])

Larger firm size favours the attainment of higher TFP. The model controls for the number of employees in a firm. There is a strong positive link between firm size and the level of TFP. Like TFP, the number of employees per firm is arranged in deciles, the biggest firms being in the 10th decile. All else being equal, their chances of achieving higher TFP are more than double those of firms in the lowest (smallest-firm) decile.

Chart 3.7

Firm size favours efficiency

Odds of achieving higher firm-level TFP by firm size



Note: Logisitic regression (Base model)

Source: Commission services based on the CompNet database

Click here to download chart.

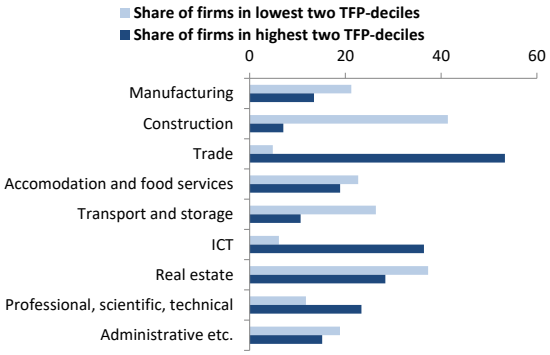
The financial crisis had a dampening impact on productivity. To control for the business cycle, 15 years of observation (2002-2016) are taken into account. A dummy variable assumes the value of one for the years from 2009 to 2013 – the years of the financial crisis and the subsequent recession. All else being equal, the chances of achieving higher TFP during these years are one third lower than what they were in non-crisis years.

Different sectors are not equally capable of achieving a higher TFP. When analysing TFP, taking into account sector-specific differences is essential. This is because a firm's capacity to achieve efficiency gains through using innovative techniques varies with the nature of its business. For example, thanks to online trading which involves customer-action and therefore requires less factor input by firms, the Trade sector achieves far-above average TFP. *Chart 3.8* shows that Trade-firms are over-represented in the highest two TFP-deciles of all firms (the 20% of firms where TFP is the highest). On the other hand, only few Trade-firms belong to the lowest two deciles. Sectors which traditionally depend on a high input of both physical and human capital, such as Manufacturing or Construction cannot benefit from the same possibilities.

Chart 3.8

The nature of a firm's business is related to its TFP potential

Share of firms of a sector in the lowest two and the highest two deciles of all firms



Source: CompNet database

Click here to download chart.

Higher wages go hand in hand with higher TFP. Firms were also regrouped into deciles w. r. t. the level of labour costs per worker. *Chart 3.9* shows the statistical chances of a firm's belonging to a higher TFP-decile, depending on the labour cost decile to which that firm belongs. From the base model specification (blue) a positive (and progressively increasing) link between wages and TFP can be clearly identified. This finding holds under 'everything else being equal' conditions. That is, it holds after taking account of the fact that labour costs and TFP are different for different firm sizes, in different sectors, and in different countries. There is hence a supplement firms pay on wages for higher productivity (TFP).

3.3. Adding other variables to the base model

This section adds additional explanatory variables to the base model. ([194]) The following findings emerge:

Firm-specific wage premiums are linked to a firm's TFP and make the wage distribution more progressive. *Chart 3.9* shows that wages contain a supplement which is related to TFP. The CompNet-variable 'wage premium' is defined as the difference between a firms' labour cost per person from the sector median ([195]). When estimating TFP, this premium can be included as another independent variable. In that case the link between labour costs and TFP changes. As the green line in *Chart 3.9* shows, the link becomes much less progressive compared with the blue line which does not include the wage premium as separate variable. In other words, the productivity-

([193]) Apart from the variables mentioned in the following, country effects are also included in each regression to control for differences across countries and for statistical noise which affects firm-information in different countries differently. Firm-data from 16 EU countries is included. Belgium, Croatia, Czech Republic, Finland, France, Germany, Italy, Lithuania, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden.

([194]) In order not to cross too many variables in one equation it is avoided that the additional variables overlap in one model. They will thus be included one by one. Each regression only controls for the variables of the base model. See Annex 5.

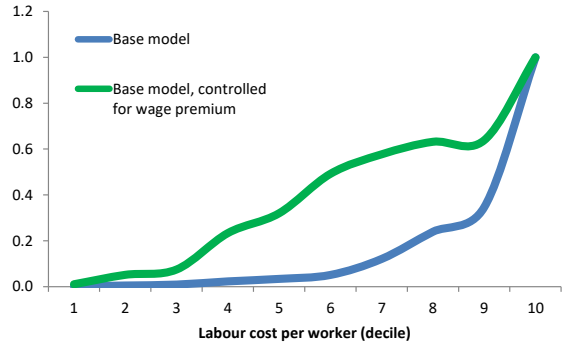
([195]) CompNet (2018), p. 73.

related supplement changes the wage distribution towards workers in those firms where TFP is high (i.e., the most innovative and efficiently working firms).

Chart 3.9

Wages bear a premium for high efficiency

Odds of achieving higher TFP by labour cost decile (highest decile=1)



Note: Ordinal logistic regression

Source: Commission services based on the CompNet database

Click here to download chart.

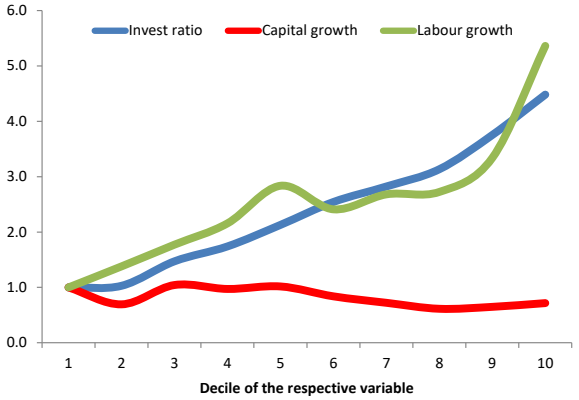
The productivity-related wage premium is thus likely to cause some wage inequalities. A number of variables can capture unequal wage distributions. It is possible to compare the wages at the top of the wage distribution with those at the bottom. How to define 'the top' and 'the bottom'? For example, one could consider 'the top' firm the one paying higher wages than 90% of firms in the respective sector. Correspondingly, wages paid by the bottom firm are lower than in 90% of all firms in the same sector. Alternatively, one could assume a threshold of 75%, instead of 90%. ([196]) The ratio between the top and the bottom wage would then be an indicator of wage inequality. Another indicator could be the overall skewedness of the wage distribution as explained above ([197]). For all these indicators, the analysis finds that wage inequality is significantly correlated with the wage premium; higher TFP goes hand in hand with higher wage inequalities. These inequalities happen because the wage premium rewards workers in efficiently working firms for their high productivity. However, *Annex 4* reveals that there is no such link between higher TFP and *total* disposable income inequality. This is because low-wage earners may be supported by social transfers. The EU's welfare systems thus reduce inequalities through re-distribution of primary income.

Replacing old with new capital is accompanied by efficient production. *Chart 3.10* shows the chances of achieving higher TFP by decile of firms' year-on-year investment ratio (blue) and capital growth (red). The difference between these two variables is the depreciation rate (capital consumption). Depreciation is included in the investment ratio and captures investment made not to increase the capital stock but to replace 'old with new' capital. The chart shows the ratio of chances of achieving higher TFP per decile, relative to the lowest decile for which the respective chances are normalised to a value of 1.

Chart 3.10

Modernising the capital stock fosters high TFP

Odds of achieving higher TFP by labour growth, capital growth and investment activity (in deciles, lowest decile=1)



Note: Ordinal logistic regression
Capital growth: Growth of the capital stock / capital stock
Invest ratio: (Capital growth + depreciation) / capital stock (CompNet (2018)

Source: Commission services, based on the CompNet database

Click here to download chart.

Unlike capital growth, total investment has a strongly positive link with TFP. The replacement component in investment strongly pushes efficiency in production as replacement may be 'an important vehicle for introducing new techniques' ([198]) while a pure increase in the capital stock may also substitute for TFP rather than support TFP-growth. ([199]) These results are in line with Musso (2006) who found a strong positive impact of capital depreciation on TFP in the US. This is because higher depreciation rates can signal shorter capital life cycles and thus higher pressure to modernise a firm's productive equipment. ([200])

Exposure to international competition increases efficiency in production. This holds true even after taking account of the size of firms ([201]). It is known that "new exporters display [not only] a productivity [but also] a size advantage" ([202]) compared with firms that do not export. There are two major reasons why exporting firms are more productive. First, they need to be more productive in order to be able to pay the costs related to trade "so that expansion into foreign

([196]) Outliers in the top decile of the wage distribution could skew the results.

([197]) The skewedness (S) measures deviation from normal distribution of wages. It is negative if high wages have a relatively high weight, positive if low wages are more numerous. In the OLS regression of TFP with skewedness as one explanatory variable, its coefficient is negative and highly significant. That is, lower S (higher share of high wages) would trigger TFP.

([198]) Aldcroft, D.H. and Fearon, P. (1969), "Economic Growth in Twentieth Century Britain", p. 45.

([199]) Burda and Severgnini (2018) come to a similar conclusion in the context of Germany's East-West convergence.

([200]) Busso, P., (2006), Capital Obsolescence, Growth Accounting and Total Factor Productivity", Revue de l'OFCE 2006/5 (no. 97), p. 217-233. See https://www.cairn.info/revue-de-l-ofce-2006-5-page-217.htm#

([201]) The firm size is controlled for as part of the base model (see previous section).

([202]) European Central Bank (2017), p. 86-87.

markets is profitable". ([203]) Second, the stronger the competition a firm faces in a market, the less flexibility it has to increase the price for its products and the more it is forced to organise its production efficiently. Firms that sell their products in the world market face global competition. Correspondingly, the regression analysis confirms that firms engaged in export activities attain higher TFP than those firms that serve only domestic markets. The box explains this result in technical terms.

Export activity fosters TFP

CompNet offers a number of variables that capture a firm's export activity. One dummy variable measures whether or not a firm is at all engaged in export activities. Those firms have a much higher chance of achieving higher TFP rates than other firms. ([204]) This finding is in line with the literature that sees firms in tradable sectors being more exposed to competition and therefore forced to increase efficiency in production. Therefore, productivity in tradable sectors tends to be higher. ([205])

Efficiency can go hand in hand with high quality labour. Higher capital growth (see red line in *Chart 3.10*) seems to dampen TFP. ([206]) Firms cannot rely just on capital deepening to improve efficiency of production. High quality labour input is crucial as well. The green line in *Chart 3.10* shows that labour growth tends to go hand in hand with higher TFP. Rather than engaging in jobless growth based solely on capital, the most innovative firms seem to attract more workers and create jobs with innovative up-to date capital. This finding is in line with the capital-skills-complementarity ([207]) found in earlier ESDE editions: well-qualified workers attract smart capital. Both high-quality labour and capital raise productivity and allow for higher wages.

Access to capital is important for innovation. Physical investment in a firm's capital stock, be it replacement or expansion, requires access to the capital market. CompNet takes into account whether or not firms face constraints when borrowing from the capital market. Four criteria define a credit constraint (CompNet (2018), p. 47):

– The firm reports loan applications which were rejected;

– The firm reports loan applications for which only a limited amount was granted;

– The firm reports loan applications which were not pursued by the firms because the borrowing costs were too high;

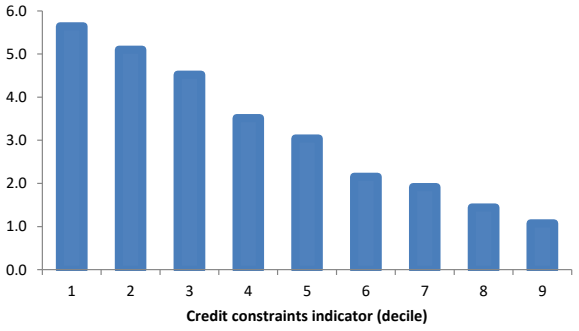
– The firm did not apply for a loan for fear of rejection (i.e. discouraged borrowers).

Even after controlling for firm size ([208]) the link between credit constraints and TFP is straightforward: the higher the credit constraints the lower is their likelihood of achieving higher TFP. This finding underlines the importance of efficient credit markets that guarantee access to credit for innovative, productive firms.

Chart 3.11

Access to capital is crucial for efficiency

Odds of achieving higher TFP by credit constraint status (in deciles, highest decile=1)



Note: Ordinal logistic regression

Source: Commission services based on the CompNet database

Click here to download chart.

Labour market imperfections reduce efficiency. The CompNet database includes an indicator for the degree of labour market imperfection at firm level.

Measuring labour market imperfection

This indicator is equal to the difference between a firm's markup ([209]) on intermediate products and the markup on labour input according to Dobbelaere and Mairesse (2013). This means that the 'intermediate input market can be seen as competitive benchmark'. ([210]) In other words, unlike labour, intermediate products can be traded, and their price tends to be a direct outcome of demand and supply. Differences between the markup of intermediate products and labour may therefore hint at imperfections in the labour market and potential market failure.

Labour market imperfections have many faces. Imperfections imply that productive factors are not used where they are most productive. There are numerous examples:

– Discrimination against certain groups of workers may create entry barriers to the labour market.

([203]) Ibidem, p. 87.

([204]) The statistical odds for exporting firms are actually four times as high. Another variable measures whether firms belong to the respective sector's top-10-exporters. In this case the odds rate from the point of view of these top-exporters is 5:1.

([205]) For example: Mano and Castillo (2015), esp. p. 23.

([206]) A simple OLS regression on continuous values (rather than deciles) for TFP as dependent variable results in a significant negative coefficient for capital growth.

([207]) See, European Commission (2018b), Chapter 2.

([208]) The number of employees is included in the base model, see Chart 3.7 above.

([209]) The markup is the ratio between the output (production) and the input of a certain productive factor.

([210]) CompNet (2018), p. 48.

These can keep even well-qualified workers out of the market or force them to work below their qualifications (dual labour markets).

– Inflexible wage structures can keep wages from rising if there is strong labour demand or from falling during a recession.

– Market power may be unevenly distributed between firms and workers (monopolies or monopsonies).

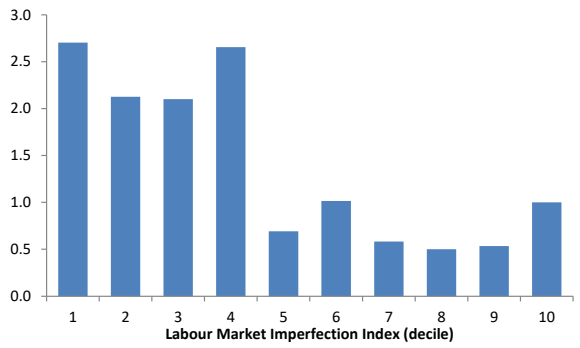
– In all these cases, wages will not reflect workers' productivity. ([211]) If there is a positive wedge between wages and productivity (ie the wage is 'too high' for certain activities), workers may be motivated to pursue these activities instead of others where their productivity would be higher. As a result, labour market imperfections can lead to the inefficient allocation of productive factors. TFP will then decline, i.e., the same factor input can generate only lower output, and hence lower growth.

Such distortions tend to weigh on TFP. *Chart 3.12* shows that firms where TFP is high tend to be those where labour market imperfections are low and vice versa. It is important to note that this finding is not related to the size of the firm, nor can it be explained by country-specific imperfections. These effects have been controlled for in the underlying regression.

Chart 3.12

Labour market imperfections exist at the expense of TFP

Odds of achieving higher TFP by degree of labour market imperfection (in deciles, highest decile=1)



Note: Ordinal logistic regression

Source: Commission services based on the CompNet database

Click here to download chart.

3.4. Summary

– **Efficient firms pay higher wages.** Efficient firms produce jobs and pay a productivity premium to their workers. There is little evidence that higher wages hamper TFP. Both go hand in hand (note that this finding holds after controlling for the size of firms).

– **Modernising the capital stock increases TFP.** Rather than simply relying on more capital, highly productive firms invest in high-quality, innovative capital that makes them more competitive.

– **Exposure to global competition raises firms' TFP**. Higher efficiency enables firms to create more jobs and pay better wages to workers. For the trade within the EU this finding underlines the importance of the EU Single Market. Its proper functioning 'stimulates competition and trade, improves efficiency [and] raises quality'. ([212]) That is, it calls for structural reforms on product and service markets that improve their functioning by increasing fair competition amongst firms. ([213])

– **Labour market imperfections go at the expense of efficiency.** Similar to product market imperfections, imperfect labour markets also tend to lower TFP. Those imperfections have many facets. Workers with non-standard contracts may be excluded from certain social protection rights or may receive wages at different level from what would be justified by their productivity. Others may not even have access to the labour market because they do not have the right skills, or, as certain categories of migrants, may not be allowed to work. These situations create dual labour markets with privileged, well protected workers on the one hand, and outsiders on the other hand. The latter may be talented. They could potentially add a lot of value to the production. Yet they are forced to stay out of the labour market or work (and paid) below the level of their skills and qualifications.

– **It is therefore important to offer equal opportunities in the labour market to all workers.** Labour market imperfections limit efficiency in production. They can be the result of discrimination or exclusion from job- or training-opportunities so that some may not have the chance to join the labour market and engage in productive activities, thus remaining idle or working in low-productivity jobs. These dynamics lead to lower growth and hinder marginalised individuals and groups from achieving their potential in the labour market and in society.

– The next section explores how policies can actively support strong productivity growth and higher wages.

([211]) To put is as in Dobbelaere and Mairesse (2013): "... input factors' estimated marginal products are often larger than their measured payments" (p. 33, 34).

([212]) See European Commission on https://ec.europa.eu/growth/single-market_en

([213]) Traditional Schumpetrian models had claimed that competition, by reducing monopolist rents, also reduce firm's incentive to innovate. However, this view has given way to new evidence that supports the notion of competition incentivising produce and process innovation (Nicodème and Sauner-Leroy, 2004, esp. pp. 12 and 13).

Table 3.4

In the eyes of managers innovation, good working conditions and training help boost productivity

Odds rate for a firm of having higher labour productivity growth

	Specification:		1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Basic model															
1	Establishment is part of ...	The private sector	0.74	0.69	0.73	0.75	0.69	0.73	0.76	0.72	0.74	0.74	0.73	0.74	0.74	0.75
		The public sector	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	Number of employees in establishment	10-49	0.70	0.76	0.76	0.79	0.66	0.73	0.69	0.76	0.63	0.68	0.70	0.64	0.70	0.72
		50-249	0.99	1.00	1.02	1.04	0.96	1.00	1.00	1.01	0.94	0.99	0.99	0.94	0.99	1.00
		250+	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	Establishment is a member of any employers' organisation which **participates in collective**	Yes	0.98	1.04	0.97	0.94	0.99	0.97	0.92	0.97	1.01	0.98	0.97	1.01	0.98	0.97
		No	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Country effects included		yes													
	Specific tests															
4	Since the beginning of 2010, has the total **number of employees** has..	Increased		2.71												
		Decreased		0.56												
		Stayed about the same		1												
5	Since the beginning of 2010 has this establishment introduced any new or	Yes			1.84											
		No			1											
6	Since the beginning of 2010, has this establishment introduced any new or significantly changed processes (**process innovation**)?	Yes				1.93										
		No				1										
7	Percentage of employees are **older than 50** years of age?	Less than 20%					1									
		20% to 39%					0.89									
		40% to 59%					0.79									
		60% to 79%					0.61									
		80% to 99%					0.40									
8	Percentage of employees working in jobs which require at least one year of on the job learning in order for the person to become proficient in his/her task (**high skill requirements**)?	Less than 20%						1								
		20% to 39%						1.15								
		40% to 59%						1.10								
		60% to 79%						1.05								
		80% to 99%						1.12								
9	Who decides by whom tasks are to be performed (**work autonomy**)	Team members decide							1.21							
		Tasks are distributed							1							
10	In the past 12 months, what percentage of employees have received on the job **training?**	Less than 20%								1						
		20% to 39%								1.20						
		40% to 59%								1.30						
		60% to 79%								1.54						
		80% to 99%								1.45						
11	Since the beginning of 2010, the general **work climate** in this establishment…	Improved									7.50					
		Remained about the same									2.18					
		Worsened									1					
12	High level of **sickness leave**?	Yes										0.83				
		No										1				
13	Difficulties finding employees with the required skills?	Yes											1.11			
		No											1			
14	A need to reduce staff?	Yes												0.41		
		No												1		
15	Collective wage agreement exists?	Yes													1.00	
		No													1	
16	Employees Representation: A structure exists in the establishment?	Yes														1.05
		No														1

Source: Commission services based on Eurofound's European Company Survey 2013

Click here to download table.

4. SUPPLEMENTARY EVIDENCE FROM A COMPANY SURVEY

A series of regressions on data from the last available (2013) European Company Survey (ECS) ([214]) for all 28 Member States confirms earlier findings that a firm's success largely depends on its human capital: workers' qualifications, their access to training and their potential to innovate.

Table 3.4 presents the results of a logistic regression on ECS firm-level data. It shows the chances that a firm's manager considers labour productivity in her/his firm to have improved ([215]) from the beginning of 2010 until 2013, the year of the survey and in which labour markets in the EU started recovering. The table shows these for a variety of variables. For each variable, it presents the chance of perceived improvements in productivity in the form of a ratio

([214]) The ECS is done every four to five years by the European Foundation for the Improvement of Living and Working Conditions. For an overview see Eurofound (2015).

([215]) The possible replies were: since 2010, productivity (1) improved, (2) stayed the same, (3) worsened. The odds ratio is the odds of the manager replying (1) or (3) relative to the odds of replying (2). This ratio is assumed equal the odds of replying (2), relative to the odds of replying (3).

relative to a reference group, which is marked in red and normalised to a value of 1.

There are 14 different model specifications for alternative variables included as explanatory variables in the regression. Four variables describe the firm and, as part of the basic model, they are thus included in all 14 specifications.

4.1. Main findings

Collective bargaining and employee representation do not seem to affect managers' perceptions of labour productivity. Whether or not an organisation participates in collective wage bargaining (row 3) does not significantly affect a firm's perceived productivity growth performance in any of the model specifications. This finding does not support the concern, often argued by managers, according to which collective bargaining, by supporting workers' bargaining power, raises labour costs and thus reduce firms' incentives to hire or retain workers. Correspondingly, whether or not workers in the firm are covered by a collective wage agreement at any level (company, sector, occupation, cross-sectoral) does not seem to impact productivity gains as managers perceive them (row 15). On the contrary, the chances of increasing productivity growth tend to be higher in firms where there is some form of employee representation (row 16) ([216]). A higher training-intensity and better working conditions may contribute to this finding. Indeed, Chapter 6 finds that firms with an employee representation perform significantly better on a series of indicators that measure the quality of work.

Good working conditions clearly support productivity. Improving the working climate (row 11) and promoting workers' autonomy (row 9) correlate very strongly with higher productivity growth. The same is true for low sick leave incidence (row 12), an indicator that correlates strongly with good (perceived) working conditions. ([217])

Innovation boosts productivity. Two ECS variables capture innovation: if a firm has invented new products or services since 2010, this could be considered a proxy for product innovation (row 5), or it could otherwise have introduced new processes, including organisational or production processes ('process innovation' - row 6). In both cases, an innovative firms' chance of achieving higher productivity growth is almost the double that of non-innovative firms.

Training helps to improve productivity as it makes workers more efficient and increases the firms' innovative capacity (row 10): the more workers have had access to training during the last 12 months, the higher a firm's labour productivity growth tends to be. This may reflect the direct effects of enhanced workers' skills and better matching, as well as indirect effects due to their contributions to product and process innovation.

In the eyes of managers an older workforce does not support productivity growth. In establishments where the proportion of workers aged over 50 is high, managers tend to expect lower productivity growth. The effect of ageing on productivity is controversially discusses by scholars, and research in this area is still in its infancies. ([218]) However, the finding confirms most recent evidence that a changing age distribution in Europe towards older ages may reduce labour productivity mainly through the channel of lower TFP growth. ([219]) If this result holds more broadly, increasing productivity growth in an ageing society emerges as a challenge ([220]) that calls for policies with a focus on training of older workers and on innovation through R&D. ([221])

4.2. Summary

Managers perceive productivity growth to be higher in firms where:

- Better working conditions support higher productivity (good working climate, workers' autonomy, few incidences of sick-leave).
- New products are invented or new processes introduced, confirming that innovation boosts productivity.
- Workers tend to be younger.
- Workers have regular access to training.

5. Strengthening Human Capital: A Model-Based Analysis

The Commission's Labour Market Model (LMM) is used to describe the transmission path of productivity-enhancing policy measures in the labour market and the economy, for a given country. ([222])

([216]) In firms where there is some kind of employee representation the odds of having higher labour productivity (as perceived by managers) is 5% higher. This odds ratio is significant at a level of 10%.

([217]) A regression analysis based on Eurofound's 6th Working Conditions Survey (2015) reveals that job satisfaction (the dependent variable) is significantly negatively clinked to the number of days on sick leave (controlled for age, gender, education, firm-size, and country-effect).

([218]) International Labour Office (2015)

([219]) Aiyar et al (2016), p. 18.

([220]) The European Commission (2017b) dealt with the challenge of ageing for the fairness across generations (ESDE 2017).

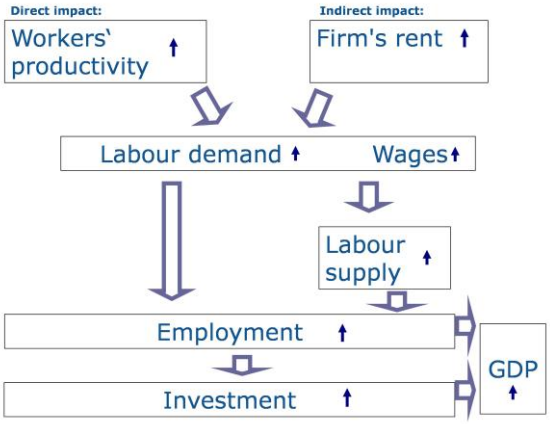
([221]) Ibidem, p. 19.

([222]) Currently, LMM supports 15 Member States, any of which can be taken as the country where the policy measure is taken. For a description of LMM see Berger et al (2009).

5.1. How a training subsidy impacts on the economy: the transmission path

The LMM is used to simulate the long-term impact of a government subsidy to firms in order to promote job-related training for workers. The subsidy tends to raise firms' incentive to offer such training to their employees and some of them will take up training. The chart depicts the transmission path of such training subsidies in LMM.

Chart 3.13
Training improves workers' productivity
Direct and indirect impact of a subsidy granted to firms in order to encourage them to offer training to workers



Note: Transmission path of a training subsidy into the economy
Source: Commission Services, based on EMPL's Labour Market Model (Berger et al, 2009)
Click here to download chart.

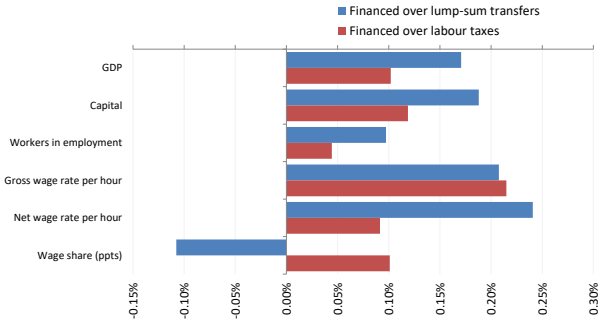
The higher uptake of training increases workers' productivity directly. As a result, firms have a stronger incentive to hire more workers. Labour demand thus increases, pushing up wages. Higher market wages will attract more workers who were previously unemployed or inactive to take up a job. Hence employment increases. As there are more people working, firms step up investment as they equip the additional workers with capital. Both higher employment and higher investment boost productivity and hence GDP.

A government subsidy increases both workers' and firms' rent. Besides the direct productivity-related impact, there is an indirect transmission path. Notwithstanding the subsidy's original purpose, it is a transfer from the government to the private sector. It thus increases (as would any other transfer to companies) the rent of a firm-worker-match. It therefore provides an additional incentive for firms to create jobs, and it makes them more conciliatory when it comes to bargaining on wages, i.e. the subsidy tends to reduce the cost of the employee-firm relationship so that they bargain less hard on wages than without the policy measure. As a result, depending on the relative bargaining power of workers and firms, part of the additional firm-worker-rent is transferred to workers in the form of higher wages.

5.2. Labour taxes matter: beware of the impact on net wages

A medium-sized training subsidy: *Chart 3.14* shows the long-term results of such a measure along the above-described transmission path, which is similar for all the countries the LMM covers. The results are shown for Belgium, where it is assumed that the government spent 0.1% of GDP per year on a subsidy incentivising firms to offer more training to their employees. A distinction is made as concerns the financing of the training subsidy. In order not to alter the allocation of resources between capital and workers, funding could take place through levying a lump-sum tax on all households. Alternatively, the government could raise the necessary funding through increasing labour taxes.

Chart 3.14
Investing in higher productivity: labour taxes matter
Grant a subsidy to firms in order to encourage them to sponsor training to workers: 0.1% of GDP, alternative funding regimes, Belgium



Source: Commission services based on EMPL's Labour Market Model
Click here to download chart.

While higher productivity leads to higher growth, workers' take-home pay may decline. Under both funding regimes the economy sees increases in GDP, employment, labour productivity (the difference between the two), and wages along the lines described above. However, the long-term impact on GDP is almost twice as strong in the more 'worker friendly' way of funding through lump-sum taxes. The relative impact on (gross) wages is nearly the same in both cases. However, in the case of labour-tax funding, the increase in workers' take-home pay (net wages) would be less than half as strong due to higher labour taxes.

A positive impact on labour supply is stronger if increased labour taxes are avoided through alternative financing. Lower net wages reduce the incentive for workers to join the labour market. For a given level of labour demand, the effect on employment is lower than would be the case if the government decided to finance the subsidy via neutral lump-sum taxes, as will be the additional investment because there are fewer workers to be endowed with new capital. Finally, with employment and net wages increasing by much less than investment, the labour-tax funded subsidy will reduce the wage share in GDP. The share of workers' rent in GDP will therefore decline while firms' share will increase.

Investment in skills creates a win-win situation for firms and workers, yet there are nuances. Investment in workers skills will pay out for both firms and workers. For firms the firm-worker-match will yield a higher return as productivity increases. Workers will also get their share of this welfare surplus as they will be able to bargain more successfully for higher wages than before the measure. The relative change in their improvement will however depend on the policy's distributive impact. Higher labour taxes will reduce workers' net wages which may have an impact on labour market participation.

5.3. Targeted training opportunities help low-qualified workers

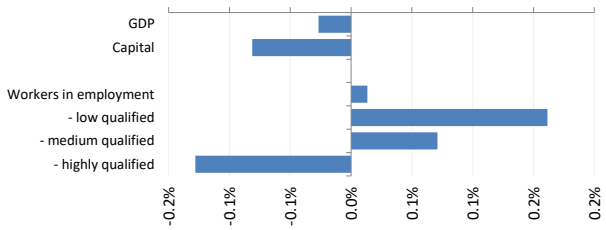
Lower-qualified workers need more incentive to take up training. LMM distinguishes a worker's qualification and her skills. While *qualification* refers to the formal level of education, *skills* are specific competences and abilities that are relevant for her job. The two concepts are closely linked. Indeed, the take-up of training to improve job-specific skills depends a lot on the qualification of workers. The lower the level of the qualification, the lower workers' lifelong learning activity tends to be. ([223])

Governments may offer new training opportunities. The government may therefore consider targeting the subsidy specifically on low and medium-qualified workers because they are more likely to be in need of skills upgrades as their take-up of training is much lower than that of tertiary-educated workers. ([224]) *Chart 3.15* shows the long-term impact on Belgium's economy and its labour market. It is assumed that the subsidy be funded via higher labour taxes (borne by all workers).

Chart 3.15

Training for lower-qualified workers improves their labour market performance

Grant a subsidy to firms in order to encourage them to sponsor training to workers, 0.1% of GDP, targeted to low- and medium-qualified workers, Belgium



Note: Assumption: The measure is financed through higher labour taxes.
Source: Commission services based on EMPL's Labour Market Model
Click here to download chart.

A focus on lower-qualified workers pushes their employment. More training granted to lower-qualified workers increases their productivity. However, workers compete with each other in the labour market. This also holds true across different qualification levels. In other words, lower-qualified workers are imperfect substitutes for better-qualified workers but if they increase their productivity, they become more attractive to firms. The latter will thus hire more low- and medium qualified workers. As a result, their wages will increase. Attracted by higher wages, low- and medium qualified workers will feel a stronger incentive to join the labour market while highly-qualified workers' employment declines. The latter are affected by higher wage taxes while not being targeted by the measure. There is thus a structural effect on employment away from highly qualified towards lower-qualified workers. In other words, the (formal) qualification level of the workforce decreases on average because of the expansion of training for low-qualified workers in particular, pulling down average productivity.

Capital and qualifications are complementary. So a decrease in average qualification levels has knock-on effects. It will induce firms to invest less because capital and qualifications are complementary. In other words, firms feel less inclined to invest in innovative capital if employment of well-qualified workers declines. As highly qualified workers have higher wages, their declining number reduces the wage share of workers in GDP (despite lower investment).

The distributional impact of training targeted on the most vulnerable remains favourable. The training subsidy will strongly improve low-qualified workers' employment prospects, thus increasing their wages. It would thus have favourable implications for Belgium's low-qualified workers whose employment rate is currently one of the lowest in the EU. They would improve competitiveness, labour market performance and wages. However, the particular design of such targeted policy measure may come at the cost of lower productivity of the workforce as a whole. It is thus necessary to design the focus of Active Labour Market Policies, training measures carefully, in particular, keeping in mind both general economic targets as well as social objectives such as fair wages and inclusiveness.

5.4. How to help the most vulnerable while boosting innovation?

In this section, simulation is performed to complement the targeted training subsidy by an additional incentive for young students. The latter are granted a scholarship for the take-up of tertiary-education study. ([225]) As in the above example, 0.1% of GDP is spent. However, instead of spending the entire amount only on a training subsidy for low- and medium-qualified workers, it is assumed that only half of it (0.05% of GDP) will be spent on that purpose. The other half will be used to fund scholarships for incentivising the take-up of relevant tertiary-education studies.

More highly qualified workers as a result of the scholarship. The training component of the policy

([223]) European Commission (2018a), Chapter 3.

([224]) See Chart 6.4 in Chapter 6.

([225]) A similar measure was simulated in last year's ESDE for the Czech Republic (European Commission (2018b), Chapter 2).

would support low and medium-qualified workers' productivity performance as described above. In addition, the study-scholarship would induce more young workers to engage in studies and thereafter work in a job that requires higher qualifications. In the long run, the share of highly qualified workers in total employment would therefore increase. This would trigger Belgium's innovative capacity and its workers' average productivity.

Chart 3.16

A policy mix that includes support to highly qualified

Grant a subsidy to firms in order to encourage them to sponsor training to workers, 0.1% of GDP, alternative target groups, labour-tax funded, Belgium

Source: Commission services based on LMM

Click here to download chart.

A balanced investment strategy that also includes the best qualified serves both economic and social targets. The less favourable impact on the workforce's average qualification that was the result of the training-only policy is avoided in the policy scenario that includes the student support. While 'training only' would reduce average productivity, in the case of 'studies included' the workforce would on average become more innovative, thus more productive than in the initial (do-nothing) situation. A higher share of highly qualified workers triggers additional capital investment so that GDP increases. A balanced investment strategy helping the most vulnerable while also fuelling innovation thus helps achieve both economic growth and social targets.

5.5. European Social Fund+ (ESF+) : an EU policy instrument promoting growth in the EU – a simulation exercise

New and old challenges call for policies that improve access to training. The findings so far reveal that higher productivity calls for adapted education and training systems. Everyone should have access to training in order to avoid labour market imperfections in the form of segmented labour markets. The employment situation in the EU has improved since 2013. Yet in many regions the levels of long-term and youth unemployment are still significant. In addition, too often jobs fail to pull people out of severe low-income conditions. Despite recent improvement, the proportion of employed people at risk of poverty and social exclusion still stands at 12%. ([226]) These factors produce outsiders largely cut off from opportunities in the labour market, thus undermining the foundations for present and future growth and ultimately challenging the sustainability of Europe's social model.

ESF+ is investment for socially sustainable growth. Established in 1958, the European Social Fund (ESF) is one of the EU's main financial instruments for supporting national policies that seek to increase employment, improve quality and productivity at work, and reduce social exclusion and regional employment disparities. ([227]) In May 2018, the Commission adopted a proposal for a European Social Fund Plus (ESF+) for the next programming period 2021-2027. ([228]) The Commission's proposal aims at helping Member States achieve (i) a skilled and resilient workforce, (ii) high employment levels, and (iii) fair social protection (see Art. 3 of the ESF+ Regulation). *Table 3.5* gives an overview over the respective investment plan. In line with these three general objectives, the ESF+ will concentrate its investment in three main areas: education, employment and social inclusion and health. The proposal foresees a total investment of EUR 88.6 billion in today's prices (EUR 101.2 billion in current prices). According to the Commission's proposal, more than half of the funds (62%) would be allocated to Less Developed Regions ([229]).

Table 3.5

ESF+: almost €89 billion in today's prices to be spent between 2021 and 2027

Commitment appropriations for the ESF+ by region type for 2021-2027, million Euro in 2018 prices

	Investment in education	Investment in employment	Investment in social inclusion
Less Developed Regions	22056.1	25206.9	15754.3
Transition Regions	5100.9	5829.6	3643.5
More Developed Regions	3869.2	4421.9	2763.7

Source: Commission Services

Click here to download table.

This section attempts to provide further evidence on the potential impacts of this ESF+ investment. ([230])

5.5.1. Distinguishing structural from demand effects

Estimating the long-term economic impact of ESF-spending is challenging. Projecting the effect of regional investment on the EU's economy, its society and the environment is extremely complex. First, regions are closely intertwined in economic terms, whether within a sector or across various

([226]) Eurostat EU SILC (series ilc_peps02) for 2017.

([227]) Available at: https://ec.europa.eu/regional_policy/en/policy/what/glossary/e/european-social-fund

([228]) European Commission (2018c).

([229]) In Less Developed Regions, GDP per capita is less than 75% of the EU average; Transition Regions have a GDP per capita between 75% and 90% of the EU average, while in More Developed Regions GDP per capita is above 90% of the EU average.

([230]) A detailed description of the analysis presented in this section with all the assumptions and sensitivity analysis will be provided in the JRC report Kancs, D. and Piroli G., "Economic Impacts of the European Social Fund Plus: A Model-based Assessment", JRC Working Papers Joint Research Centre, European Commission, (forthcoming).

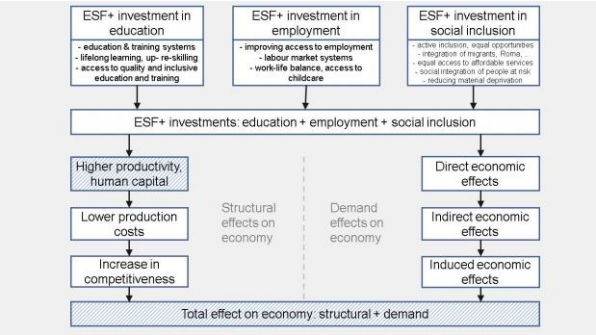
sectors. Second, there may be a long time-lag between the investment being made and its return flowing back. This is typically the case with the support of training or education. Three types of potential economic effects of ESF+ investments are of particular interest in the context of the 2021-2027 measures: (i) demand effects (e.g. hiring of workers and teachers); (ii) structural effects (e.g. productivity and human capital growth); and (iii) macroeconomic effects (e.g. on GDP and employment). In line with the focus of this chapter, the main emphasis of the analysis is on structural effects, especially the impact on productivity.

The immediate effects of ESF+ spending on aggregate demand tend to be measurable. When the ESF+ invests in education and training, the observable effects include the number of teachers or the number of administrative staff required for training new students and trainees, additional textbooks needed, or costs of school utilities and maintenance. In *Chart 3.17* these directly measurable effects are referred to as the *demand effect on the economy*.

Chart 3.17

Demand and structural effects of ESF+ spending on the economy

Mechanics of ESF+ impact on the EU's economy



Source: Commission Services (Joint Research Centre)

Click here to download chart.

Structural effects are not directly measurable. Measuring how many new firms are created by newly educated or trained workers or the impact of their post-training professional activities on their productivity is more difficult. In *Chart 3.17* these not directly measurable effects are referred to as the *structural effect on the economy*. These structural effects are overlain by other simultaneous developments and policies, making it extremely challenging to establish a causal link to ESF+ investments. Given that it is very difficult to measure them on a case-by-case basis, another model-based scenario analysis is provided for simulating how GDP and productivity would evolve with and without the ESF+ investment. ([231])

([231]) The spending under the ESF+ programme for the period 2021 to 2027 may overlap with measures under the previous ESF programming period (2014 to 2020). This modelling exercise looks only at the potential impact of future (ESF+) spending, notwithstanding any other measures that may have been implemented in addition to ESF+.

Causal effects of ESF+ spending are difficult to measure. This section undertakes a model-based tentative endeavour to quantify how macro-variables may react in the future with and without ESF+ interventions. ([232]) It then draws conclusions from the differences between the two scenarios.

Total effects of ESF+ investments on the economy, as shown in *Chart 3.17*, are referred to as the sum of structural and demand effects. Providing evidence for a causal effect of European Cohesion Policy measures on the economy is challenging. Important magnitudes such as output, consumption, trade, employment or GDP may be observable. Yet the impact of increased ESF+ spending on these variables is blurred by various coincidental effects that may neutralise or confound each other.

5.5.2. *Simulation results: productivity increases while unit labour costs decline*

The impact of ESF+ investment as shown in *Table 3.5* is estimated for labour productivity.

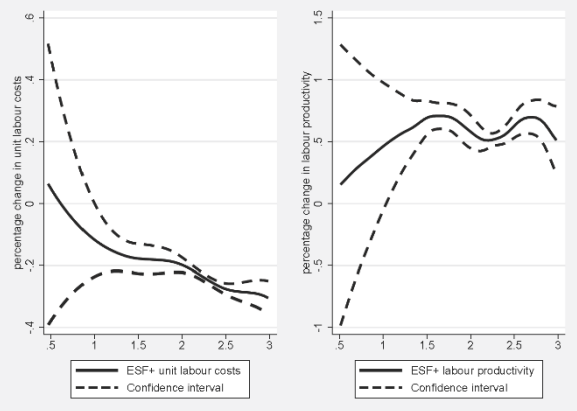
ESF+ increases labour productivity, and lowers unit labour costs. *Chart 3.18* shows, on the vertical axis, the simulated impact of ESF+ spending on unit labour costs (left panel) and labour productivity (right panel). ([233]) This strand of impact was referred to as *structural effects on the economy* (*Chart 3.17*). *Chart 3.18* shows the estimated impact, which depends on how much is actually spent on the ESF+ measures. Therefore, the horizontal axes of *Chart 3.18* show the intensity of the 'treatment' (the level of ESF+ investment). There is a certain error probability in these estimations. To capture the degree of uncertainty, the dashed lines in *Chart 3.18* frame the estimation in what is called a confidence interval. ([234])

([232]) The analysis is not to be interpreted as a forecast, nor is it a fully-fledged in-depth impact assessment of ESF+ spending.

([233]) The simulation uses data from the previous programming period 2014 to 2020. It follows a non-parametric approached explained in Kancs and Siliverstovs (2016 and 2019).

([234]) The estimation of the impact is based on a sample. It is therefore not known for sure that it is the true parameter. The significance level is assumed at 95%: Imagine one draws 100 such samples. In this case the impact as calculated from the samples will be 95 times within the corridor as framed by the dashed lines in the chart.

Chart 3.18
ESF+ supports labour productivity
Results: estimated impact of ESF+ on unit costs (left) and productivity (right)



Source: Commission Services (Joint Research Centre)
Click here to download chart.

The following results emerge:

- ESF+ spending tends to support labour productivity and lower unit labour costs. Unit labour cost is the ratio between labour costs and productivity. Hence, part of the decline in unit labour costs is due to higher productivity. ESF+ will therefore improve the EU's competitiveness.

- This result becomes more uncertain the lower the assumed ESF+ spending intensity is. Indeed, the confidence intervals (dashed lines) suggest that at low ESF+ intensities the estimated policy impact is not significantly different from zero. Only when a certain critical mass is reached does the ESF have a statistically significant impact on unit labour costs and productivity.

The impact of ESF+ on productivity is non-linear. However, the estimated impact is not a straight line. In other words, it cannot be assumed that increases in the intensity (the level of expenditure) will change productivity or unit labour costs in a linear manner. This is because there are two margins of adjustment to such a policy shock: the increasing headcount of workers and the improvement of their skills and qualifications.

ESF+ programmes help disadvantaged workers to improve their labour market performance. Both effects may work in the opposite direction. The reason has already been outlined in the previous section. Where training incentives are improved (only) for lower-qualified workers, ESF+ spending may change the structure of the workforce towards more lower-qualified workers. For example, the social inclusion strand of ESF+ also includes support for people from disadvantaged communities, such as migrants and Roma, in order to increase their labour market participation. These workers typically have lower-than average qualification profiles.

5.5.3. GDP increases, especially for Less Developed Regions

The impact on Less Developed Regions is higher. The estimated ESF+ impact on labour productivity is used as input into a macroeconomic model ([235]) to simulate the impact on GDP (to which *Chart 3.17* has referred as *total effect on economy*). The resulting change of GDP, relative to the baseline, is shown in *Chart 3.19* for Less Developed, More Developed and Transit Regions. The aggregate impact of ESF+ investment on GDP is positive for all three groups of regions. However, the impact is higher the lower the level of the regions' development. This finding can be explained by the fact that ESF+ spending in less developed regions can be a significant proportion of overall spending.

ESF+ triggers positive spill-over effects. There are significant spill-over effects across regions and sectors, including on those not directly benefiting from the ESF+ investment. ([236]) This is due to:

- cross-border and cross-sectoral trade of goods and services. It is likely that there will be fiercer competition between firms of different regions or sectors due to the crowding-out of less competitive firms by new firms that emerge as a result of the enhanced ESF+ spending (*indirect economic effects*, see *Chart 3.17*);

- labour migration and capital flows and

- spill-overs of knowledge and the spatial diffusion of technology.

Investment may take time before revealing its full impact. The full positive effect of ESF+ investment on GDP lags by several years. This is because it takes time for the impact of education and training programmes to materialise in the form of higher productivity and thus higher GDP growth. The time-lag implies that, in the first years, the program's cost (see the bars in *Chart 3.19*) is higher than its positive economic effect on GDP. Indeed, in the short-run the *demand effect* (see *Chart 3.17*) dominates as modernising classrooms, building new schools and hiring additional teachers drives government consumption immediately.

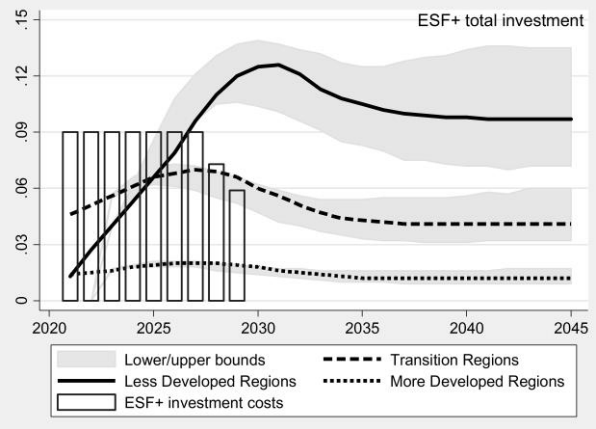
In the long-term, structural effects support growth more strongly. Only when the structural effects (higher productivity growth) start materialising does the policy-induced GDP growth accelerate and eventually exceed the costs. In the long run, the effect on productivity (and GDP) will decline somewhat, assuming that no further intervention is made after

([235]) The employed macroeconomic model is described in the JRC Technical Report: Ivanova, O., Kancs D., and Thissen, M. (2019): European Economic Modelling System, JRC Working Papers, Joint Research Centre, European Commission.

([236]) See the evidence about the impact of Cohesion Policy in previous programming periods' as presented in European Commission (2017a), p. 186.

the end of the programme in 2027. However, although the measure stops in 2027, there will be a lasting positive impact on productivity and GDP which could amount to around 0.1% of GDP in Less Developed Regions

Chart 3.19
ESF+ spending supports GDP, especially for Less Developed Regions
Simulated impact on GDP (percent increase relative to the baseline)



Source: Commission Services (Joint Research Centre)
Click here to download chart.

The financing of ESF+ investment matters for its impact. As shown in the previous section in the example of a training subsidy, the allocation of labour (and capital) depends on whether labour taxation finances the ESF+ investment. There is no such direct link for the funding of ESF+. Similarly to the entire EU budget, ESF+ has certain sources of financing that in the model are traced back to taxes paid by households and business in each Member State and region. Part of the required ESF+ funding comes from extra household savings, part of it comes from a borrowing abroad, and yet another part is derived from relocating existing savings that might have been invested differently.

5.6. Summary

The long-term macroeconomic impact of training support granted to firms has been analysed (on the example of Belgium). Firms receive a subsidy which motivates them to offer more training to their workers.

- **Training increases workers' productivity, thus labour demand and wages.** However, the way the subsidy is financed matters a lot for workers' income. If funded through an increase in labour taxes instead of neutral lump-sum levies on every household, the positive impact on workers' take-home pay is less strong. This is because higher labour taxes lower net wages. This is a disincentive for workers to join the labour market. The employment impact is therefore lower in the case of labour-tax funding.

- **Human capital investment should be well balanced across target groups.** Instead of granting support to all workers, the subsidy could be focused on lower-qualified workers, knowing that they are mostly in need of training. In that case, their wages would increase as a result of higher productivity. However, overall productivity could decline, as more workers could feel attracted by higher wages in the low-qualification segment and would therefore not invest in higher qualifications. In that case, more low and less higher-qualified workers were in employment. The average qualification of workers of all workers would thus decline, pulling down investment because qualifications and capital investment are complementary. The effect on GDP could well, therefore, be negative.

- **Supporting higher studies boosts productivity.** The government could avoid the negative side effect of a lower average qualification level of workers by strengthening incentives to invest in higher qualifications. In addition to the training subsidy, it could support the take-up of higher studies through a scholarship. In that case, the average qualification could increase, raising the economy's investment and its innovation potential.

- **Investment in human capital through ESF+ is expected to trigger growth.** ESF+ spending as programmed for the period 2021 to 2027 is expected to boost workers' productivity and firms' competitiveness in the long run. As workers become more productive, this helps firms to reduce unit labour costs. Significant governmental cost in the short run will be followed by lasting positive GDP effects in the long run.

- **These findings underline the importance of EU initiatives in the area of skills.** The New Skills Agenda for Europe was launched in June 2016 and comprises ten concrete action plans, from adult upskilling initiatives aimed at strengthening vocational training and education (VET) to sharing best practice. ([237]) Reforms in these areas attract a lot of policy attention. Within the framework of the European Semester, 22 out of 28 Member States have received Country-Specific Recommendations in the area of Education and Skills, VET and Adult Learning in 2018.

6. Main findings in brief

In line with earlier ESDE analyses ([238]), in a context of a serious demographic challenge and fast-changing working patterns, the EU needs to speed up its productivity growth.

Growth should rely more on the efficient use of resources in order to be sustainable. Given the scarcity of natural and human resources, productivity

([237]) See https://ec.europa.eu/social/main.jsp?catId=1223.
([238]) European Commission (2017b) on intergenerational fairness, see esp. Chapter 2. European Commission (2018b) on Digitalisation and the World of Work, see Chapters 2 and 3.

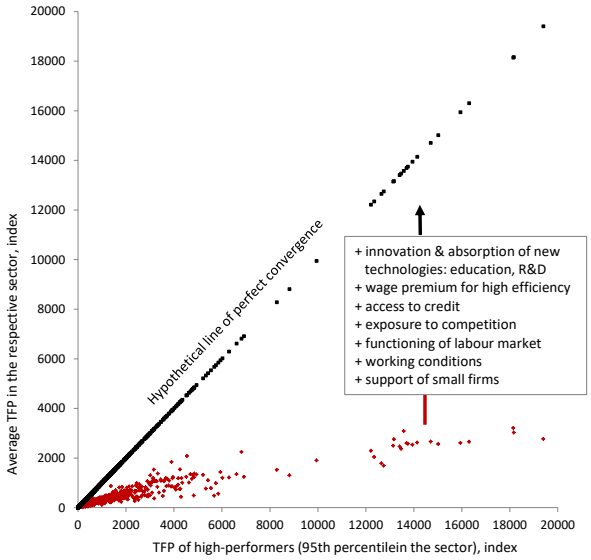
growth should rely more on the efficient use of existing productive factors than on increasing factor input.

Are there ways to increase efficiency? This chapter explores the driving forces of productivity, especially Total Factor Productivity (TFP), as a measure of innovation and efficiency in production. Its main findings are illustrated in *Chart 3.20*. Each point represents a sector in a given year and a given country. It shows the sector's average TFP and how far it is away from the sector's technological frontier. The chart summarises the points, which, according to this chapter's findings, promote the catching-up process.

Chart 3.20

Factors promoting higher efficiency: human capital counts.

Firms in CompNet by sectors: Sectoral average TFP performance (red) and the technololical frontier (black)



Note: The technological frontiers are considered those firms that are at the 95th percentile of the sector's TFP distribution
Data from 2004-2015.
Each point represents a sector in a given country and a given year (n=9.190).

Source: Commission illustration based on CompNet data

Click here to download chart.

In particular, the chapter finds:

- At regional level: lagging regions catch up in terms of TFP performance under certain conditions.
- The overall growth in TFP has significantly decreased in the last two decades, especially in some regions of Southern Europe, as in Italy.
- There is a significant dispersion of regional TFP performance across Europe, although Eastern Europe has been catching up over the last 20 years.
- Investment in Research and Development and the availability of well-qualified workers have a direct positive impact on regions' innovation potential.
- TFP-differences across regions can be considered as an opportunity for growth in those regions that still lag behind today. This is because they can absorb benchmark regions' innovative technologies. The transfer of new ideas helps them grow faster themselves. Indeed, all else being equal, the further away a region is from reaching the technology benchmark the larger its own TFP growth potential tends to be. Both research-orientation and the availability of qualified labour facilitate a region's capacity to absorb benchmark technologies from other regions.
- The perceived effectiveness of Government intervention also strengthens a regions' TFP performance, a finding that confirms the factor analysis presented in Chapter 2.
- There is a tendency for TFP performance to converge also at firm level. Similarly to regions, the further a firm lags behind the technological frontier, the higher its TFP potential growth. Within a sector, the more firms that are close to the frontier, the higher are the chances of other firms increasing their efficiency through learning and absorbing new technologies.
- Firms working efficiently pay significant wage premiums to workers for more efficiency in production. Everything else being equal, the wage premium increases progressively with increasing TFP. Reducing wage differentials would require investing in those workers who are trapped in low-productivity activities with little access to the resources necessary to improve their qualifications and job prospects.
- While the efficiency premium is significant, there is little evidence that higher TFP increases overall disposable income inequality ex post. The EU's social transfer systems seem to mitigate primary-income inequalities stemming from TFP differentials.
- There is little evidence that high wages hamper competitiveness. This has implications for employment as well. Indeed, all else being equal, highly efficient firms tend to raise employment. There is no obvious trade-off between efficiency in production and employment.
- Increasing a firms' capital stock may not necessarily increase TFP. It may also serve as a substitute for TFP-growth. On the other hand, modernising a firm's productive capital (replacing 'old by new' capital) tends to foster TFP. Innovative capital makes firms more productive.
- All else being equal, smaller firms tend to work less efficiently. It is therefore important to improve their access to resources that allow for innovative investment. In that context, insufficient access to credit has a significantly negative impact on TFP. On the other hand, this chapter has also shown that investment in training and qualifications helps to increase productivity. This is important in the context of small firms because their workers seem

to have scarcer access to training than their colleagues in larger organisations (see Chapter 6).

– All else being equal, labour market imperfections are a drag on TFP. These include segmented labour markets with groups of workers excluded from major opportunities such as decent wages or training. In those cases, outsiders may either be trapped in unemployment or motivated to search for jobs where their wages are not in line with their productivity. As a result, human resources and capital are not allocated where they are most productive. Lower TFP and lower growth are the consequence.

– In the eyes of managers, favourable working conditions (a good working climate, workers' autonomy, low sick leave incidences) as well as process- and product innovation are conducive to higher productivity.

Furthermore, model-based policy-simulations suggest:

– Supporting firms in their efforts to offer productivity-enhancing training to their workers yields a high and lasting return. For workers, it increases their wages and improves their job prospects. Firms enjoying higher profits through increased productivity are able to strengthen their competitiveness.

– Improving access of low-qualified workers to training increases their wages in line with higher productivity. It may thus help those workers who are most in need of support. However, as employment prospects of low-qualified workers improve, their numbers may increase, so that the average qualification level of workers may decline, pulling down overall productivity. Therefore, incentivising the take-up of higher level studies as part of the policy mix boosts innovation and increases overall productivity, employment and hence GDP.

– EU Cohesion Policy is expected to boost both the EU's productivity and its growth performance, especially in its Less Developed Regions. This finding is the result of a tentative simulation, based on the example of spending under the European Social Fund Plus (ESF+) programme, as foreseen for the next programming period 2021-2027. It confirms studies that have assessed the impact of the ESF in earlier programming periods. ([239])

([239]) See European Commission, Supporting the Impact Assessment of Human Capital Investments (Final Report, May 2018), esp. p. 44.

7. Conclusions and policy choices

Lagging regions and firms tend to catch up in terms of efficiency, but workers' qualifications are crucial in that process. The analysis has showed that higher efficiency in production does not come only from investing in more or better capital. Workers and their qualifications also play an important role for two reasons. First, they determine the potential of firms and regions to innovate. Second, they determine their potential to absorb new high-end knowledge from the technological frontier. This is important for regions and firms lagging behind in terms of their productivity performance. These tend to grow faster, but the speed of catching up depends on the availability of human capital, notably well-educated, highly-skilled workers and on the resources devoted to Research and Development.

Policies that focus on education and training help to boost productivity growth. Such investment would help the most vulnerable while also fuelling innovation. It is shown to boost both employment and productivity, hence triggering further capital investment complementary to better trained, better qualified workers. In this context, the ESF+ investment plan, as proposed by the Commission for the period between 2021 and 2027, is likely to have significantly positive economic effects especially in those regions that today lag behind in economic terms. Yet, much of the expected positive impact depends on whether both firms and workers have access to the resources necessary to be innovative. For firms, this implies improving access to capital, especially for small companies. For workers, it implies opening up segmented labour markets that discriminate against outsiders by keeping them away from the labour market, away from decent working conditions and away from developing the necessary tools to upskill.

Annex 1: The concept of Total Factor Productivity

The conventional approach for TFP considers that output is a function of labour input L, capital input K, and a factor TFP capturing the degree of efficiency at which labour and capital are used in production. The conventional Cobb-Douglas model is therefore the following:

$$Y_{r,t} = (L_{r,t})^{\alpha} \cdot (K_{r,t})^{(1-\alpha)} \cdot TFP_{r,t} \quad (1)$$

where $Y_{r,t}$ is real output (Gross value added) in region *r* at time *t*, $K_{r,t}$ is the (physical) capital stock and $L_{r,t}$ the total labour input (labour volume measured as total hours worked by workers) at the regional level. α and (1 - α) are the output elasticities of labour and capital input, respectively. For the regional analysis of section 2 it is assumed, in line with Behnabib and Spiegel (2005), that α = 1/3.

TFP is 'the proportion of output not explained by the amount of inputs used in production'. ([240]) Thus, with TFP being a residual, ΔTFP > 0 would imply that an increase of production would thus not come from a mere increase of input of K and L, but would also capture a certain productivity dividend from a more 'efficient and intense' use of inputs in production. ([241]) For example:

- A certain amount of capital may be installed in a firm, but it may be obsolete or its capacity may not be fully used.
- A certain volume of labour may be employed, but workers could become more innovative through training.
- Re-organising work my yield higher output even with a given stock of capital and a given number of workers.

TFP is thus **a better indicator for efficiency than labour productivity**. To demonstrate, one can divide (1) by labour input L:

$$\frac{Y_{r,t}}{L_{r,t}} = \left(\frac{K_{r,t}}{L_{r,t}}\right)^{(1-\alpha)} \cdot TFP_{r,t} \quad (2)$$

The left-hand side of (2) shows labour productivity, that is: Output per unit of labour. On the right-hand side one can see that labour productivity depends on TFP, but also on the input levels K and L. ([242])

([240]) Comin (2010), p. 260 or Lopez-Garcia et al (2015), pp. 24, 25. TFP is thus calculated as a residual. There are other methods to estimate TFP (parametric and non-parametric estimations).

([241]) Ibidem.

([242]) As marginal productivity of labour declines with higher labour input so would (average) labour productivity. On the other hand, more capital input would augment production per worker.

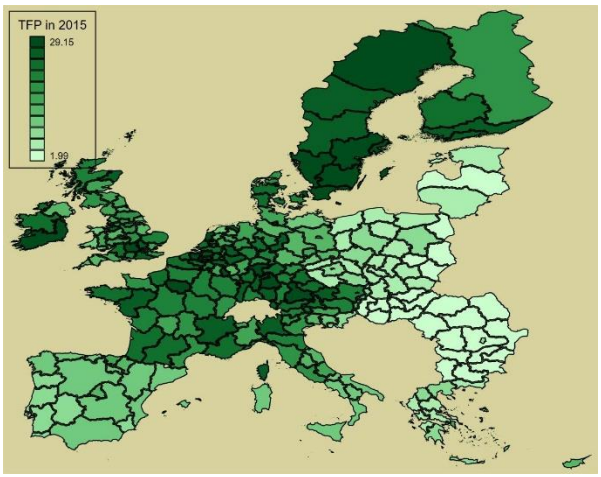
What does TFP look like in the regions?

Figure A1.1 maps, in eleven classes, the level of TFP in 2015 for EU-regions. There is a significant difference between core and peripheral regions. The regions with the higher performance in TFP are Inner London West (29.15) ([243]), Southern and Eastern Ireland (13.70), Stockholm (13.34), Inner London East (13.33), Luxembourg (12.51) and Île de France (11.86), while Severen tsentralen (2.10), in Bulgaria, Nord-Vest (2.07) and Sud-Vest Oltteniaex (1.99), both in Romania, exhibit the lowest levels.

Figure A1.1

TFP in EU regions: High dispersion

Total Factor Productivity (TFP) in 2015



Note: Data for Croatia not available

Source: Commission services based on data from Eurostat, Cambridge Econometrics, EU-KLEMS and national sources (for BE and PT)

Click here to download figure.

([243]) This value should be considered as an outlier.

Annex 2: Determinants of regional TFP – a regression analysis

Regional TFP estimates are used to test the existence of regional convergence in TFP on the basis of the Benhabib and Spiegel's framework ([244]). The approach also takes into account a region's degree of industrial specialisation and its expenditure in Research and Development (R&D):

$$T\dot{F}P_{r,t} = b_0 + b_1 lnH_{r,t-1} + b_2 lnH_{r,t-1} * \left(\frac{TFP_{r,t-1}}{TFP^*_{r,t-1}}\right) + e_{r,t} \quad (2)$$

where $T\dot{F}P_{r,t}$ represents the annual growth in TFP of the region r at time t. $H_{r,t}$ is human capital, calculated as the average number of years of schooling. The final term proxies a region's the capacity to absorb technology that comes from a leader region r^*. ([245]) The intuition of the model is that human capital increases productivity growth of a region *per se* by fostering innovative activities as in Romer's (1990) endogenous growth model. The higher a region's level of human capital the higher will be its productivity due to its augmented innovative capacity.

However, regions also grow due to the transfers of technology and knowledge from the technology frontier. In the second part of the equation, human capital interacts with the TFP gap in order to capture the absorptive effect that human capital is expected to have on these technology transfers.

The larger the TFP gap to the technology frontier the higher is TFP growth because "more" technology is available to be absorbed from the technology frontier. However, in order to be able to benefit from this technology, the receiving region needs a certain level of absorptive capacity.

Model (2) is extended by two additional variables:

$$T\dot{F}P_{r,t} = \beta_0 + \beta_1 lnH_{r,t-1} + \beta_2 R\&D_{r,t-1} + \beta_3 KSI_{r,t-1} - \beta_4 lnH_{r,t-1} * \left(\frac{TFP_{r,t-1}}{TFP^*_{r,t-1}}\right) + e_{r,t} \quad (3)$$

where $KSI_{r,t}$ represents the Krugman Specialisation Index ([246]), which compares the industrial structure of the region with the rest of the EU ([247]). The index takes value zero if the region has an industrial structure identical to the reference region, indicating that region is not specialized, and takes a maximum value of 2 if it has no sectors in common with the rest of the EU, reflecting strong sectoral specialization, according to the following formula for six sectors i:

$$KSI_{r,t} = \sum_{r,t}^{i} ABS\left[\frac{X_{r,i}}{X_r} - \frac{X_i - X_{r,i}}{X - X_r}\right] \quad (4)$$

$R\&D_{r,t}$ ([248]) is the intensity of the expenditure in Research & Development and represents a region's attitude towards innovation.

([244]) Benhabib and Spiegel (2005).

([245]) Due to the choice of using a logistic diffusion function for the TFP catch up analysis, we expect a negative sign for the coefficient b_2 meaning that higher levels of human capital interacted with the TFP gap lead to faster TFP growth. For a discussion of the different functional form which can be used in this context, see Benhabib and Spiegel (2005).

([246]) The Krugman Specialisation Index (KSI) is described in Mongelli et al (2016), p. 29

([247]) Usually this index is calculated using gross value added or GDP, but we prefer to use employment due to the fact that, having only data for six sectors, it shows higher variability then the index calculated by output, although being highly correlated.

([248]) R&D is Intramural R&D expenditure (GERD) taken by Eurostat and represents the total of the regional expenditure in R&D as percentage of gross domestic product. The human capital is measured accounting the number of schooling years according to the shares in employment by three different levels educational attainment level. All data are regional specific. Missing Eurostat data in R&D and human capital are filled using simple interpolation methods depending on the specific case (proportion or average).

Annex 3: A model for convergence using CompNet data

A regression estimates the change of TFP over time. For TFP, the CompNet-variable used for the analysis is 'tfp_va_macCD'. It is based on the broader sector's value added (as opposed to firm revenue) and assumes a Cobb-Douglas production function.

Let d signal the difference of the respective variable between a given year t and t-4. Then $d\ln(TFP)$ is the (logarithm of the) change of TFP over a four year period up to the current year t. Correspondingly, $d\ln(w)$ is the change in wages, measured as labour costs per worker.

One could consider a sector's benchmark firm as the firm at the 95th percentile of the TFP distribution. One would then measure the distance to the benchmark as the TFP difference between that firm (TFP_{p95}) and the average TFP_m of the respective class. A class are all firms of the same sector, same year, same size group.

The regression further controls for the skewedness of the distribution within a class, using the skewedness γ of its distribution. A dummy variable takes the value of one if γ<0, zero otherwise. That is, if the mass of the distribution is on the right side of the distribution, this would imply that there are many firms with relatively high TFP performance in the same group of firms.

A dummy variable controls for the crisis years up to 2013. Finally a last dummy captures the firm size: it takes the value of one if the firm belongs to the 20% smallest, zero otherwise. The model specification is thus:

$$\begin{aligned} d\ln(TFP) = {} & \beta_1 * d\ln(w) + \beta_2 * \ln\left(TFP_{p95} - TFP_m\right) \\ & + \beta_3 * DummyRightSkew \\ & + \beta_4 * DummyCrisis \\ & + \beta_5 * DummySmallFirm \\ & + constant \end{aligned}$$

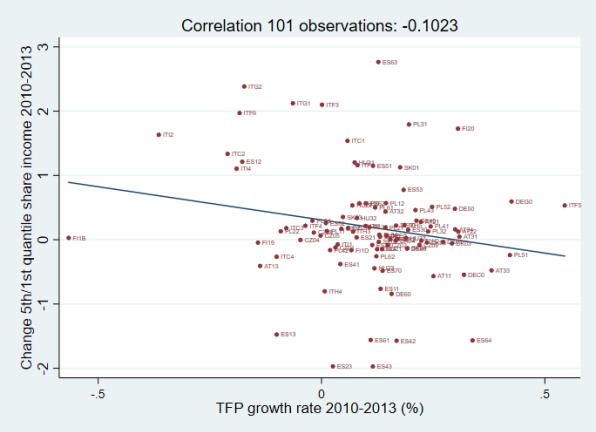
Annex 4: TFP growth and income inequality

TFP growth may raise wage premiums but may not necessarily raise income inequality, mainly thanks to social transfers. Savoia (2019) found that European regions have converged to higher levels of income inequality during the period 1989-2013. ([249]) This study had provided two indicators of inequality that are used in the following to explore the link between income inequality and Total Factor Productivity at regional level. ([250]) These are:

– the share of the richest, relative to the poorest 20% of the population in total disposable income (that is, the income share of the 5th relative to the 1st income quintile);

– the Gini index of disposable household income (that measures inequality in the entire income distribution).

Chart A4.1
TFP growth between 2010 and 2013, plotted against quintile ratio change (5th relative to 1st quintile)

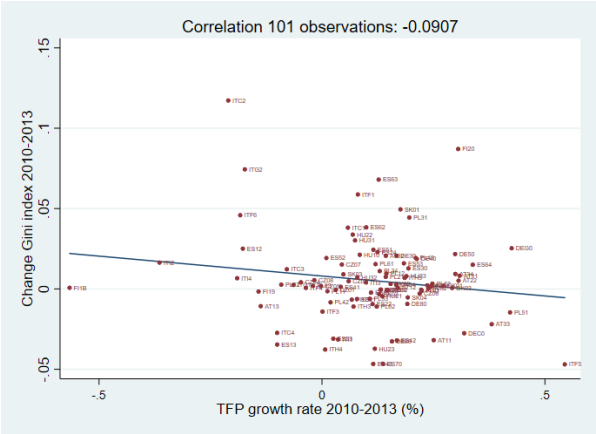


Source: Commission Services based on Eurostat EU SILC
Click here to download chart.

For the period between 2010 and 2013 the chart looks at EU regions at the level of NUTS-2. It plots the regions' change in TFP against the change in both inequality indicators and calculates the correlations: They are weak, even negative: -0.1 and -0.09, respectively.

This finding suggests that even though productivity premiums are paid on wages, an increase in productivity will not necessarily lead to higher *income* inequality, taking into account the effect of social transfers in balancing out part of these inequalities. Indeed, earlier Commission analyses had demonstrated that the EU's redistributive systems reduce (disposable) income inequality significantly. ([251])

Chart A4.2
TFP growth between 2010 and 2013, plotted against Gini coefficient change



Source: Commission Services based on Eurostat EU SILC
Click here to download chart.

([249]) The study also shows that the Cohesion Policy seems to have significantly accelerated the pace of convergence.

([250]) Both indicators are calculated from different waves of the Luxemburg Income survey (LIS).

([251]) See European Commission (2017b), pp. 41-42.

Annex 5: Logistic regression on CompNet data

Table A5.1

Logistic regression, odds rates

Model specifications for the regression on CompNET data; Independent variable: Firm-level TFP

Odds rates of being in a higher TFP decile, relative to the respective refrence group (highlighted in red and normalised to a value of 1)

		Source-File in CompNet	jd_l								jd_invest_ratio		jd_t10_exp_country (manufacturing)		jd_dummy_exp (manufacturing)	
		Model specif.	1	2 (Base)	3	4	5	6	7	8	9	10	11	12	13	14
[CRISIS=.00]	Crisis	No	0.9	1.5	1.2	2.1	1.6	2.1	2.1	1.1	1.3	1.1	1.4	1.8	1.4	2.6
[CRISIS=1.00]		Yes	1	1	1	1	1	1	1	1	1	1	1	1	1	1
[size2=1.00]	Firm Size (1)	Size 10-49									0.0	0.0	0.0	0.0	0.0	0.0
[size2=2.00]		Size 50-249									0.1	0.1	0.1	0.0	0.1	0.0
[size2=3.00]		Size 250+									1	1	1	1	1	1
[NoOfEmployees=1]	Firm Size (deciles)	1	0.3	0.3	0.7	0.3	0.4	0.3		0.7						
[NoOfEmployees=2]		2	0.3	0.4	0.7	0.4	0.4	0.4		0.7						
[NoOfEmployees=3]		3	0.3	0.4	0.7	0.4	0.4	0.4		0.7						
[NoOfEmployees=4]		4	0.4	0.5	0.7	0.5	0.4	0.5		0.7						
[NoOfEmployees=5]		5	0.5	0.5	0.8	0.5	0.5	0.5		0.7						
[NoOfEmployees=6]		6	0.5	0.5	0.8	0.6	0.5	0.5		0.7						
[NoOfEmployees=7]		7	0.6	0.6	0.8	0.6	0.6	0.6		0.7						
[NoOfEmployees=8]		8	0.7	0.7	0.9	0.8	0.7	0.7		0.7						
[NoOfEmployees=9]		9	0.8	0.8	0.9	0.8	0.8	0.8		0.8						
[NoOfEmployees=10]		10	1	1	1	1	1	1	1	1						
[LabCostPW=.00]	Labour costs (deciles	1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
[LabCostPW=1.00]		2		0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
[LabCostPW=2.00]		3		0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0		0.1	0.0	0.1	0.0
[LabCostPW=3.00]		4		0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1		0.1	0.0	0.1	0.0
[LabCostPW=4.00]		5		0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1		0.2	0.0	0.2	0.0
[LabCostPW=5.00]		6		0.1	0.5	0.0	0.1	0.0	0.0	0.1	0.2		0.3	0.0	0.3	0.0
[LabCostPW=6.00]		7		0.1	0.6	0.1	0.1	0.0	0.0	0.1	0.3		0.3	0.0	0.5	0.0
[LabCostPW=7.00]		8		0.2	0.6	0.2	0.2	0.0	0.0	0.3	0.4		0.8	0.0	0.9	0.1
[LabCostPW=8.00]		9		0.3	0.6	0.4	0.3	0.2	0.2	0.4	0.6		1.0	0.2	1.1	0.4
[LabCostPW=9.00]		10		1	1	1	1	1	1	1	1		1	1	1	1
[WagePremium=.00]	Wage premium (deciles)	1			0.0											
[WagePremium=1.00]		2			0.1											
[WagePremium=2.00]		3			0.1											
[WagePremium=3.00]		4			0.2											
[WagePremium=4.00]		5			0.2											
[WagePremium=5.00]		6			0.2											
[WagePremium=6.00]		7			0.3											
[WagePremium=7.00]		8			0.5											
[WagePremium=8.00]		9			0.6											
[WagePremium=9.00]		10			1											
[CapGrowth1=.00]	Capital growth (deciles))	1				1.4										
[CapGrowth1=1.00]		2				1.0										
[CapGrowth1=2.00]		3				1.5										
[CapGrowth1=3.00]		4				1.4										
[CapGrowth1=4.00]		5				1.4										
[CapGrowth1=5.00]		6				1.2										
[CapGrowth1=6.00]		7				1.0										
[CapGrowth1=7.00]		8				0.9										
[CapGrowth1=8.00]		9				0.9										
[CapGrowth1=9.00]		10				1										
[CreditConstraint=.00]	Credit constraint (deciles)	1					5.6									
[CreditConstraint=1.00]		2					5.1									
[CreditConstraint=2.00]		3					4.5									
[CreditConstraint=3.00]		4					3.5									
[CreditConstraint=4.00]		5					3.0									
[CreditConstraint=5.00]		6					2.2									
[CreditConstraint=6.00]		7					1.9									
[CreditConstraint=7.00]		8					1.4									
[CreditConstraint=8.00]		9					1.1									
[CreditConstraint=9.00]		10					1									
[LMImperfection=.00]	Labour market imperfection (deciles)	1						2.7	2.2							
[LMImperfection=1.00]		2						2.1	1.8							
[LMImperfection=2.00]		3						2.1	1.7							
[LMImperfection=3.00]		4						2.7	2.3							
[LMImperfection=4.00]		5						0.7	0.6							
[LMImperfection=5.00]		6						1.0	0.8							
[LMImperfection=6.00]		7						0.6	0.5							
[LMImperfection=7.00]		8						0.5	0.4							
[LMImperfection=8.00]		9						0.5	0.5							
[LMImperfection=9.00]		10						1	1							
[LabGrowth1=.00]	Labour growth (deciles)	1								0.2						
[LabGrowth1=1.00]		2								0.3						
[LabGrowth1=2.00]		3								0.3						
[LabGrowth1=3.00]		4								0.4						
[LabGrowth1=4.00]		5								0.5						
[LabGrowth1=5.00]		6								0.4						
[LabGrowth1=6.00]		7								0.5						
[LabGrowth1=7.00]		8								0.5						
[LabGrowth1=8.00]		9								0.6						
[LabGrowth1=9.00]		10								1						
[InvestRatio=1]	Investment ratio (deciles)	1										0.2				
[InvestRatio=2]		2										0.2				
[InvestRatio=3]		3										0.3				
[InvestRatio=4]		4										0.4				
[InvestRatio=5]		5										0.5				
[InvestRatio=6]		6										0.6				
[InvestRatio=7]		7										0.6				
[InvestRatio=8]		8										0.7				
[InvestRatio=9]		9										0.8				
[InvestRatio=10]		10										1				
[Top10Exporter=0]	Top 10 exporter	No												0.2		
[Top10Exporter=1]		Yes												1		
[Dummy_exp=0]	Exporting	No														0.3
[Dummy_exp=1]		Yes														1

Note: CompNET data covering the time span between 2004 and 2016 (16 EU countries included). Example: A firm's odds of belonging to one of the higher TFP-deciles is 50% higher during non-crisis years (crisis: 2008-2013), relative to crisis-years (odds ratio: 1.5).

Source: Commission Services based on CompNET data

Click here to download table.

Table A5.2

Logistic regression, odds rates (continued)

Model specifications for the regression on CompNET data; Independent variable: Firm-level TFP

Odds rates of being in a higher TFP decile, relative to the respective refrence group (highlighted in red and normalised to a value of 1)

		Source-File in CompNet	jd_l								jd_invest_ratio		jd_t10_exp_country (manufacturing)		jd_dummy_exp (manufacturing)	
		Model specif.	1	2 (Base)	3	4	5	6	7	8	9	10	11	12	13	14
[mac=1]	Manufacturing		0.5	0.2	2.1	0.1	0.1	0.0	0.0	0.5	0.3	1.3	0.4	-	-	-
[mac=2]	Construction		0.2	0.1	0.4	0.0	0.1	0.0	0.0	0.1	0.1	0.6	0.2	-	-	-
[mac=3]	Wholesale and retail trade		13.6	6.9	31.9	8.7	6.3	5.8	5.4	19.6	16.7	56.6	36.6	-	-	-
[mac=4]	Accomodation and food services		0.3	0.1	0.4	0.0	0.1	0.0	0.0	0.1	0.1	0.7	0.4	-	-	-
[mac=5]	Transport and storage		0.4	0.5	3.7	2.2	1.0	1.7	1.7	1.7	0.8	1.2	1.2	-	-	-
[mac=6]	ICT		3.2	0.3	5.7	0.4	0.8	0.1	0.1	0.6	0.8	10.8	2.8	-	-	-
[mac=7]	Real estate		1.5	0.4	1.9	0.0	1.6	-	-	0.0	1.0	11.2	1.9	-	-	-
[mac=8]	Professional, scientific and technical activities		1.3	0.1	1.0	0.1	0.2	0.0	0.0	0.2	0.4	3.9	0.8	-	-	-
[mac=9]	Administrative and support service activities		1	1	1	1	1	1	1	1	1	1	1	-	-	-

Source: Commission Services based on CompNet data

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References

Aldcroft, D.H. and Fearon, P. (1969), "Economic Growth in Twentieth Century Britain", p. 45.

Aiyar, S., Ebeke, C. and Xiaobo, S. (2016), The Impact of Workforce Ageing on European Productivity, IMF Working Paper 16/238.

Annoni, P. and Catalina Rubianes, A. (2016), "Tree-based approaches for understanding growth patterns in the European regions," REGION, European Regional Science Association, vol. 3, pages 23-45.

Arpaia, A., Curci, N., Meyermans, E., Peschner, J. and Pierini, F. (2010), Short time working arrangements as response to cyclical fluctuations, European Economy, Occasional Papers 64, June 2010.

Benhabib, J. and Spiegel, M. (2005), Human capital and technology diffusion. Chapter 13 in: Aghion, P., Durlauf, S. (Eds.), Handbook of Economic Growth. Elsevier.

Berger, J., Keuschnigg, C., Keuschnigg, M., Miess, M., Strohner, L. and Winter-Ebmer, R. (2009), Modelling of Labour Markets in the European Union - Final Report (Parts I to IV).

Busso, P. (2006), Capital Obsolescence, Growth Accounting and Total Factor Productivity", Revue de l'OFCE 2006/5 (no. 97), p. 217-233. See https://www.cairn.info/revue-de-l-ofce-2006-5-page-217.htm#

Burda, M. C., and Severgnini, B. (2018), Total factor productivity convergence in Ger- man states since reunification: Evidence and explanations, Journal of Comparative Economics 46 (2018) 192–211. Humboldt University Berlin, CEPR and IZA, Germany; Copenhagen Business School, Denmark.

Charron, N., Dijkstra, L. and Lapuente, V. (2014), Regional Governance Matters: Quality of Government within European Union Member States, Regional Studies, 48:1, 68-90, DOI: 10.1080/00343404.2013.770141

Cohen, W. M. and Levinthal, D. A. (1989), Innovation and Learning: The two Phases of R&D, The Economic Journal, 99, September 1989, p. 569.

Comin, D. (2010), total factor productivity. In: Durlauf S.N., Blume L.E. (eds) Economic Growth. The New Palgrave Economics Collection. Palgrave Macmillan, London

CompNet (2018), (The Competiveness Research Network), User Guide for the 6th Vintage of the CompNet Dataset, Version 28.11.2018.

Dobblebaere, S. and Mairesse, J. (2008), Panel Data Estimates of the Production Function and Product and Labor Market Imperfections, National Bureau of Economic Research, Working Paper 13975, Cambridge, May 2008.

Eurofound (2015), Third European Company Survey – Overview report: Workplace practices – Patterns, performance and well-being, Publications Office of the European Union, Luxembourg.

European Central Bank (2017), ECB Economic Bulletin, Issue 2 / 2017.

European Commission (2017a), Seventh report on economic, social and territorial cohesion, Luxembourg: Publications Office of the European Union, 2017.

European Commission (2017b), Employment and Social Developments in Europe 2017, Luxembourg Publication Office of the European Union

European Commission (2018a), Study Supporting the Impact Assessment of Human Capital Investments for the Directorate-General for Employment, Social Affairs and Inclusion, by Fondazione Giacomo Brodolini (Final Report).

European Commission (2018b), Employment and Social Developments in Europe 2018, Luxembourg Publication Office of the European Union.

European Commission (2018c), Proposal for a regulation of the European Parliament and of the Council on the European Social Fund Plus (ESF+), COM(2018) 382 final, 30.5.2018.

European Environmental Agency (2017), Climate change, impacts and vulnerability in Europe 2016 – An indicator-based report, EEA Report No 1/2017.

Gardiner, B., Waights, S. and Derbyshire, J. (2011), Estimating the capital stock for the NUTS2 regions of the EU27. Applied Economics, Taylor Francis (Routledge), 2011, 45 (09), pp.1133-1149.

Hall, B.H. (2011), Using productivity growth as an innovation indicator, University of Maastricht and UC Berkeley, Report for the High Level Panel on Measuring Innovation, DG Research, European Commission.

International Labour Office (2015), Ageing and productivity, on https://www.who.int/ageing/features/productivity/en/

International Monetary Fund (2016), Central, Eastern, and Southeastern Europe: How to Get Back on the Fast Track, Regional Economic Issues, May 2016.

Ivanova, O., Kancs D. and Thissen, M. (2019): European Economic Modelling System, JRC Working Papers, Joint Research Centre, European Commission.

Kabasakal, A., Gülmez, A. and Kutlar, A. (2017), Total Factor Productivity and Efficiency in OECD Countries:

Possibility of Convergence in 2000-2012 Period. Business and Economics Research Journal. 8. 1-18.

Kancs, D. and Piroli G., Economic Impacts of the European Social Fund Plus: A Model-based Assessment, JRC Working Papers Joint Research Centre, European Commission, (forthcoming).

Kancs, D. and Siliverstovs, B. (2016), R&D and non-linear productivity growth," Research Policy, Elsevier, vol. 45(3), pages 634-646.

Kancs, D. and Siliverstovs, B. (2019), Employment Effect of Innovation, JRC Working Papers in Economics and Finance, European Commission.

Katz, L.F. (1986), Efficiency Wage Theories: A Partial Evaluation, National Bureau of Economic Research, Working Paper No. 1906, Cambridge, MA, April 1986.

Lopez-Garcia, P., di Mauro, F. and the CompNet Task Force (2015), Assessing European competitiveness: the new CompNet micro-based database, ECB Working Paper 1764 / March 2015.

Majumdar, R. (2017), Understanding the productivity paradox Behind the Numbers, Deloitte Insights.

Manca, F. and Piroli, G. (2011), Human Capital, R&D and Productivity Convergence of European Regions. A spatial analysis of RHOMOLO's semi endogenous growth approach, ERSA conference papers ersa11p816, European Regional Science Association.

Mano, C. M. and Castillo, M. (2015), The Level of Productivity in Traded and Non-Traded Sectors for a Large Panel of Countries, International Monetary Fund (IMF) Working Paper WP/15/48, February 2015.

Mathews, J. A. (2002), "Competitive Advantages of the Latecomer Firm: A Resource-Based Account of Industrial Catch-Up Strategies," Asia Pacific Journal of Management, vol. 19 (2002), Issue 4, pp 467–488.

Mongelli, F., Reinhold, E. and Papadopoulos, G. (2016), What's so special about specialization in the euro area? Early evidence of changing economic structures, European Central Bank, Occasional Paper No 168, February 2016, p. 29.

Nicodème, G. and Sauner-Leroy, J.-B. (2004), Product market reforms and productivity: a review of the theoretical and empirical literature on the transmission channels, European Economy (European Commission) No. 218, December 2004.

Norušis, M. J. (2012), IBM SPSS statistics 19 advanced statistical procedures companion, Upper Saddle River: Prentice Hall, 2012, Chapter 4 (Ordinal Regression).

Rodríguez-Pose, A. and Ganau, R. (2018), The productivity challenge for European regions, presentation given at ECFIN Annual Research Conference "The productivity challenge: Jobs and incomes in the dawning era of intelligent robots", Brussels, November 2018.

Savoia, F. (2019), Income Inequality Convergence Across EU Regions, LIS Working papers 760, LIS Cross-National Data Center in Luxembourg.

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

Thum-Thysen, A. and Raciborski, R. (2017), "Determinants of trend TFP growth and key policies that influence it," Quarterly Report on the Euro Area (QREA), Directorate General Economic and Financial Affairs (DG ECFIN), European Commission, vol. 16(2), pages 31-41, October.

Van Ark, B. (2014), Total factor productivity: Lessons from the past and directions for the future, National Bank of Belgium, Working Paper Research No. 271, October 2014.