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IS THERE A TRADE-OFF BETWEEN PRODUCTIVITY AND EMPLOYMENT?

A CROSS-COUNTRY MICRO-TO-MACRO STUDY

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Is there a trade-off between productivity and employment? A cross-country micro-to-macro study

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The impact of productivity on employment remains uncertain, particularly in light of growing concerns regarding potential negative effects of technological progress on labour demand. This report uses harmonised and comparable data from 13 countries spanning the last two decades to comprehensively analyse how productivity growth affects employment dynamics at various levels of aggregation. The study's findings highlight a positive correlation between productivity growth and employment as well as wage growth, both at the firm level and on a broader scale. This outcome arises from counteracting mechanisms and heterogeneous dynamics across different groups of firms. The findings have relevant policy implications: productivity is not just an isolated key economic objective, but well-designed and complementary policies can also help convert technological and organisational change into higher employment and wage growth.

Keywords: Productivity, technological change, employment, labour demand, trade-off

JEL codes: J23, O30, O33

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Executive summary

Productivity is a key driver of economic growth. Nevertheless, policy makers contemplating reforms to boost productivity may ask how far productivity changes translate into changes in employment and wages.

The present analysis answers that question based on data for 13 countries over the past two decades. It is a novel and uniquely comprehensive investigation of the productivity-employment nexus, at different levels of aggregation.

Results are that, on average, productivity growth is positively associated with the growth of employment and wages, *both* at the firm level and at the more aggregate levels.

At the firm level, two groups stand out. From a static perspective, firms at the top of the productivity distribution experience higher employment growth. However, after accounting for differences in productivity, initially less productive firms that increase their productivity and catch up towards the frontier experience stronger employment growth than other firms.

The results are consistent with the idea that firms improving their position relative to competitors can attract higher demand, with positive and persistent effects on employment. These indirect employment-generating dynamics appear to outweigh the direct negative effects related to higher efficiency and automation.

Productivity growth at the firm level is also positively related to wage growth, and appears to increase the probability of firm survival, thereby limiting job losses associated with firm exit.

At the more aggregate level, the role of reallocation and links across industries become more evident. Yet also here, results confirm that productivity growth is, overall, associated with positive changes in employment and wages. Increasing employment among expanding firms tends to outweigh decreasing employment in shrinking or exiting firms. Furthermore, productivity gains at the industry level contribute to stronger employment growth in downstream industries through value chains.

This suggests that boosting productivity is not only a standalone economic objective. Well-designed productivity-enhancing policies can leverage synergies across different policy areas and help translate technological and organisational change into higher employment and wages.

Policy should be oriented at fostering: innovation and its diffusion; skills; competition; reallocation while paying attention to inclusiveness; integration in value chains; aggregate demand.

Such policies would not only be beneficial for productivity but are likely to have double dividends also for employment and wages, fostering inclusive economic growth.

1 Introduction

A vast literature has shown that productivity growth is ultimately the main driver of economic wellbeing. However, the last two decades have been characterised by a slowdown in productivity growth combined with increasing divergences between the most productive firms and the rest. These phenomena have ignited a spirited debate among economists and policy makers not only on how to increase productivity growth across countries and over time, but also on how to make it more inclusive.

Even though the importance of a sustained and shared productivity growth is widely acknowledged, the extent to which productivity changes translate into employment growth is still unclear. A long-lasting debate focuses on the role of technological progress for employment and labour markets, and the extent to which it may create winners and losers in the economy. However, this debate is still ongoing, and results are mixed.

The debate on the role of changes in productivity – and technological change more specifically – for employment dynamics, as well as the existence of winners and losers, has been long lasting, dating back to discussions by economists such as Keynes and Ricardo and to policy debates at the time of Luddites. Concerns about the possible negative impacts of technological change on employment are further illustrated by recent discussions on the effects of automation. Some studies show, for instance, adverse effects of robotisation on employment and wages, and suggest that the disappearance of routine tasks from the domain of labour may increase inequality. Rapid advances in artificial intelligence and the possibility to automate an increasing set of tasks, including non-routine cognitive ones, have further fuelled public anxiety of a looming technological unemployment. Such views may support the idea of a trade-off between employment and productivity growth driven by technological progress, that would compel policy makers to find a complex policy mix to achieve both objectives at the same time.

However, technological progress does not necessarily only destroy jobs, but may also be a powerful driver of employment growth. First, new technologies may favour the emergence of new tasks in which labour can be productively employed, such as tasks related to the design, supervision, maintenance and repair of machines, tasks related to data administrators and analysts (see Acemoglu and Restrepo (2018[1])).[1] Second, firm-level adoption of technologies, even those related to automation, can generate employment gains due to increased productivity. Such productivity effects can create jobs at adopting firms that become more competitive and are able to increase sales (e.g., by charging lower prices), but may also induce employment growth at more aggregate levels through changes in aggregate demand and cross-sectoral linkages, with gains in downstream consumer industries that may outweigh direct negative own-industry effects (Autor and Salomons, 2018[2]). This may support the idea that policy makers could “hit two birds with one stone” and achieve employment growth by addressing the recent productivity growth slowdown.

Understanding the impact of productivity changes on labour markets is even more relevant nowadays in light of recent trends in productivity and business dynamics, as well as the recent COVID-19 pandemic. Studies have documented a productivity slowdown, a decline in business dynamism and a decline in the responsiveness of employment to productivity shocks. In addition, during the COVID-19 crisis, the adoption of digital technologies has been key to support firms’ activities and employment. Firms could focus on investing in product and process innovations and reorganising production, as the opportunity costs of doing so were low during the crisis when demand was low and production halted (Aghion and Saint-Paul, 1998[3]; Barlevy, 2004[4]; Bloom et al., 2021[5]). However, the consequences of the current wave of adoption of ICT-related technologies, especially those that may replace labour from production tasks, are still uncertain, with concerns about their long-term employment impact. In addition, many policies have been adopted during the COVID-19 crisis to save both jobs and firms with potential implications for employment dynamics and productivity (Calligaris et al., forthcoming[6]). Therefore, a deeper understanding of the productivity-employment nexus is of utmost importance.

In this context, a number of questions arise. Is there a trade-off between productivity and employment growth? Or can productivity growth instead contribute to boosting employment? This analysis aims at answering these questions by investigating how productivity growth relates to the dynamics of employment and wages at different levels of aggregation and over different countries, industries, and time horizons. Exploring the productivity-employment nexus can provide useful insights on a relationship that encompasses a broad range of economic mechanisms. This can inform policy makers about the extent to which boosting productivity growth may at the same time help foster employment growth, about which policies may be more likely to help achieve possible double dividends, as well as warn about trade-offs that may arise.

Looking at the productivity-employment nexus is challenging. First, productivity encompasses many facets, some of which affect employment in different ways and through countervailing mechanisms. Second, the strength and direction of productivity effects may markedly differ according to the level of aggregation considered. For instance, analyses at the firm level are usually not able to account for competitive externalities of firm-level productivity growth, associated with the exit of less productive firms and the reallocation of labour towards more productive ones. Observing such effects requires the study of either more aggregate levels or data representative of the full population of firms within an industry/country. Third, different compensation mechanisms may be at work at different levels of aggregation. For instance, reductions in production costs following a productivity increase may allow lower prices, and in turn increase sales and labour at the firm level; further, direct own-industry negative effects associated with productivity-improving technologies at the industry level may be compensated by positive spillovers on other industries. Fourth, productivity growth may affect labour demand in a dynamic way. Initial effects of technological change on employment may be different from longer-term ones, as changes in demand, adjustments to new technologies or market conditions take time and may require complementary investments by firms.

Overall, this implies that the effects of productivity on employment and wages may be heterogeneous along different dimensions as well as over time. Lack of availability of comprehensive data at different levels of aggregation, over long-time horizons across countries and industries have so far limited the scope of related analyses.

The current report aims at addressing these challenges taking advantage of the OECD MultiProd data, a unique cross-country infrastructure collecting micro-aggregated representative data based on firm-level information. Previous analyses shedding light on the productivity-employment nexus have generally focused on specific facets of productivity, or on single countries/aggregation levels (see for instance Decker et al (2020[7]) focusing on the United States or Autor and Salomons (2018[2]) using industry-level data, and a more detailed literature review below).

Thanks to the uniqueness of the data used, this report contributes to the existing literature by investigating the heterogeneity of the link between productivity growth and employment dynamics at different levels of the economy (within-industry vs. cross-industry) over a long time horizon, and from a cross-country cross-sectoral perspective. This allows to dissect the complexity of the productivity-employment nexus and the potential mechanisms at play. In particular, this analysis exploits statistics collected at different levels of aggregation to investigate the link between productivity and employment growth from two complementary perspectives: at the micro-economic level focusing on within-firm growth and firm survival, and at a more aggregate level focusing on industry-level growth and its economy-wide implications. The dataset used covers 22 SNA A38 industries in manufacturing and non-financial market services for 13 countries, over the period 2000-2018.

This report provides evidence that productivity growth is overall accompanied by employment growth across all levels of aggregation considered. As such, they represent complementary, rather than alternative, policy targets. This report therefore complements discussions of the productivity slowdown and decline in business dynamism, and suggests that addressing the structural drivers of these trends may also benefit employment.

More specifically, within individual firms, both the current level of productivity and the rate of productivity growth are positively linked to changes in firm size (i.e., the firm's number of employees) and firm survival. Therefore, firm-level productivity and productivity growth seem to secure the jobs of the firm's current workforce and create further job opportunities. Here a key mechanism is related to the firm's productivity performance relative to some of its potential competitors, i.e., firms in the same country-industry. The positive relationship between firm-level productivity growth and employment growth is indeed strongly related to the degree to which firms improve their position in the productivity ranking within their industry. In addition, leading firms at the frontier of the productivity distribution experience on average higher employment growth than less productive but otherwise comparable firms in the same country and industry.

The correlation between productivity growth and employment growth can be shaped by two opposite effects: a direct negative effect, i.e., a negative labour-saving effect due to higher efficiency which implies that less inputs (including labour) are required to produce the same amount of output; a positive indirect effect, i.e., a positive effect on employment growth due to an increase in demand experienced by firms increasing their productivity channeled by a potential decrease in (quality-adjusted) prices and, hence, an increase in sales. In this report the within-firm positive correlation between productivity and employment growth suggests that the positive indirect employment effect prevails over the direct negative one.

When looking at the link between productivity growth and changes in employment and wages at the industry level, the report finds again a positive correlation, although weaker than at the firm-level. First, this can relate to the fact that at the industry level employment gains of well-performing firms may be in part negatively compensated by losses at firms which are less productive or improve their productivity less. Second, industry-level demand may be less elastic than the firm-level one, implying that industry-level productivity gains translate into employment gains at a slower rate than at the firm-level. To corroborate this finding, additional results show that the industry-level positive link tends to be stronger when productivity growth occurs in relation to increased participation in global value chains, that is when markets expand and industry-level demand may be more elastic.

Employment growth may also be positively influenced by productivity growth in other domestic and foreign industries. When testing this hypothesis, the results show that especially productivity growth in upstream industries may stimulate labour demand further down the value chain. Stated differently, employment growth in a given industry is positively correlated to productivity growth in supplier industries, further corroborating the idea that productivity gains are on average labour enhancing not only at the firm level, but also at the more aggregate one.

Finally, the contestability of markets appears to significantly shape the strength of the positive link between productivity and employment. First, the report shows that the productivity-employment nexus is stronger in more contestable environments: a higher dispersion in market power in some industries might prevent to a certain extent firms with initially lower productivity (and hence for which productivity growth correlates more strongly with employment growth) to increase their employment as much as they would do in more competitive industries. This might be due to the fact that in environments with a lower degree of contestability these firms might not fully realise the indirect benefits associated with productivity growth, notably through sales expansion.

Overall, the evidence shown in the report suggests that labour demand and productivity represent complementary rather than alternative policy targets, and that well-designed complementary policies enhancing productivity have the potential to help translate the outcomes of technological and organisational change into higher employment and wages.

On the one hand, policy makers should support technology diffusion, boosting the potential of laggard firms to catch up, which turns out to have significant positive effects also for job creation and wages. On the other hand, policy makers should foster innovation at the frontier, also considering its important role for labour demand.

Achieving a level playing field and preserving a competitive environment is equally key in this context. This is not only crucial for productivity, but this analysis shows that asymmetric market power may also reduce the positive employment effects of technological and organisational changes. Such environment should relevantly allow leveraging spillovers arising from value chains. Indeed, the analysis highlights that productivity growth in domestic and foreign supplier sectors may strengthen employment growth in downstream sectors.

Finally, given that both productivity growth and the related job creation and wage increases occur through creative destruction, it is key to maintain an environment in which reallocation of resources occurs, while paying attention to its inclusiveness.

The rest of the document is organised as follows. Section 2 provides an overview of the existing evidence relevant to the productivity-employment nexus. Section 3 presents the data used for the analysis. Section 4 discusses the methodology adopted to investigate the relationship between productivity growth and employment growth at the level of the firm, and then presents the corresponding results. Section 5 presents the methodology and results related to the relationship at the level of detailed industries, as well as related to spillovers between industries along value chains. Section 6 discusses key takeaways and the policy implications of the empirical results. Section 7 concludes.

2 Related existing evidence

The effect of productivity growth – or more specifically of technological progress – on employment growth has been the subject of lively debates in the economic literature. These debates have been long-lasting, dating back to the Ricardian concept of "technological unemployment" moving to the Keynesian predictions of "mankind solving its economic problem" thanks to improved living standards by 2030.

Even recently, the macroeconomic literature has highlighted contradicting effects of (technology-driven) productivity shocks on hours worked at the aggregate level. In this respect, Galí (1999[8]) finds that hours worked fall in response to technology shocks while Christiano, Eichenbaum and Vigfusson (2003[9]) uncover a positive response. Basu, Fernald and Kimball (2006[10]) instead highlight the dynamic pattern of the response, showing that hours worked co-move negatively with contemporaneous productivity shocks, but then rise with a lag. All in all, conclusions from this stream of literature appear sensitive to the modelling approach adopted.

Lack of consensus at the macroeconomic level motivates the analyses – largely country-specific – focusing on more disaggregated data, which explore more in detail the nature of the relationship between productivity growth and employment growth. More granular data provide indeed additional insights on the heterogeneity of the link between productivity and employment, and the extent to which this link can change at different levels of aggregation, as well as over time and across countries. In this respect this report follows more closely this literature.

Starting from the micro-economic evidence, Baily, Bartelsman and Haltiwanger (1996[11]) focus on US manufacturing establishments over the 1980s and dissect the conventional wisdom that rising productivity is necessarily accompanied by downsizing. They find that productivity and employment can move either in the same direction or in the opposite one, with plants that increased employment and productivity contributing similarly to overall productivity growth as plants that increased productivity and reduced employment. They further discuss how this may be related to several factors, including the elasticity of demand, technological properties of the production function (e.g., returns to scale), or changes in the skill composition, all insights that are relevant for the analysis in this report.

More recently, Decker et al. (2020[7]) further focus on US firms using comprehensive longitudinal data between 1981 and 2013. They provide empirical evidence of a significant positive association between productivity and employment growth. Relevantly, they also find that the responsiveness of employment to productivity shocks has declined in recent decades, which is consistent with rising adjustment frictions.

Still at the micro-economic level, a different stream of (innovation) literature has focused on the labour demand effects of technological change, highlighting significant heterogeneity in the innovation-employment nexus, and emphasising distinct effects of different types of innovation, as well as the role of possible compensation mechanisms (see Calvino and Virgillito (2018[12]) or Vivarelli (2014[13]) for surveys). In particular, this literature documents a positive link between product innovation and employment, while the link with process innovation appears more ambiguous. Productivity-enhancing process innovations, especially those related to automation, decrease employment at constant output. However, higher production efficiency may translate into lower prices when markets are competitive, which may stimulate output and therefore labour demand. See also Aghion et al. (2022[14]), Mondolo (2022[15]), Montobbio et al. (2022[16]), Filippi et al. (2023[17]) and Hötte et al. (2023[18]) for recent surveys of the literature.

Firm-level effects of technological change on labour demand may significantly differ from more aggregate industry-level and economy-wide effects. In particular, job creation related to sales expansion for innovating firms can occur at the expense of competing firms, through market share reallocation effects (see for instance the discussion by Harrison et al. (2014[19]) about business stealing and market expansion).[2]

In this context, focusing on industry-level data across 19 countries between 1970 and 2007, Autor and Salomons (2018[2]) find that changes in total factor productivity related to cross-country industry trends (that importantly encompass technology) have a direct negative effect on employment. However, they show that these losses are reverted when accounting for indirect gains in downstream customer industries and increases in aggregate demand induced by industry-level productivity growth, suggesting that aggregate compensation mechanisms may be strong enough to offset potential negative own-industry effects. Such positive compensations across industries are also highlighted by Acemoglu and Restrepo (2018[1]; 2020[20]) and Dauth et al. (2021[21]), while less so by Dosi et al. (2021[22]).

Recent waves of innovation and robotisation have revived the debate around the effects of technological change on employment. First, the development and diffusion of ICTs may enable firms to "scale without mass", i.e., to expand sales and market shares without increasing their employment. Moreover, recent availability of detailed data on robot shipments has allowed assessing in more detail the link between automation technologies and employment.

In this context, recent contributions tend to highlight a positive employment effect of automation at the firm level (Acemoglu, Lelarge and Restrepo, 2020[23]; Aghion et al., 2020[24]; Koch, Manuylov and Smolka, 2021[25]).[3] Domini et al. (2021[26]) further find that automation spikes are linked to both higher hiring and lower separation, which together explain an increase in contemporaneous net employment growth, and are not followed by an increase in wage inequality (Domini et al., 2022[27]).

Overall, net employment growth crucially depends on the extent to which direct displacement effects are counterbalanced by positive productivity effects (Acemoglu and Restrepo, 2019[28]).The strength of such effects may however vary, and Acemoglu and Restrepo (2020[20]) suggest that these productivity effects may not always be strong enough to compensate for adverse task-replacing effects. For instance, "so-so technologies" and the "wrong kind of AI" tend to focus more on task-level replacement of workers rather than increases in productive efficiency complementing labour (Acemoglu and Restrepo, 2020[29]). Relatedly, Autor et al. (2022[30]) find that technological innovations that complement the outputs of occupations lead to the emergence of new work, together with the effect of demand shocks that raise occupational demand. Conversely, innovations that automate tasks or reduce occupational demand slow new work emergence.

For 17 OECD countries and industries, Graetz and Michaels (2018[31]) suggest that the concern that productivity effects may not always outweight task-replacing effects does not apply to the adoption of industrial robots over the period 1993-2007. They highlight instead the presence of sizeable gains in productivity and consumer rents (through lower prices) while not providing evidence for induced reductions in aggregate employment. This points, once again, to the relevance of carrying out analyses at different levels of aggregation, and at the existence of countervailing mechanisms acting in different directions.

Indeed, as also emphasised above, technological progress does not only displace labour at the task level, but can also create new tasks in which labour has a comparative advantage, generating a reinstatement effect. This is shown by Acemoglu and Restrepo (2019[28]), who highlight that changes in labour demand depend on the balance between forces of task level substitution and reinstatement. Focusing on the US, they argue that this balance has shifted in the 1990s due to the deceleration in the introduction of technologies reinstating labour and an acceleration of displacement technologies. Further, due to capital-labour complementarity, even task-replacing automation need not always have adverse consequences for affected workers if sufficiently many productive tasks remain within the occupation. To this end, in reviewing existing evidence, Lane and Saint-Martin (2021[32]) find that the types of AI adopted over the past decade is, in the aggregate, not strongly linked to adverse impacts on employment or wages.

Net employment growth, however, masks composition dynamics with technologies affecting differently the labour demand for different types of workers, demographic groups or occupations (Autor, Levy and Murnane, 2003[33]; Acemoglu and Autor, 2011[34]; Humlum, 2019[35]; Aghion et al., 2020[24]; Acemoglu and Restrepo, 2022[36]; Acemoglu et al., 2022[37]; Acemoglu, 2023[38]; Autor, Salomons and Seegmiller, 2023[39]; Georgieff and Milanez, 2021[40])[4].

Beyond technological change, demand plays an important role for productivity growth. A growing literature indeed suggests that firm-level growth (and survival) is also strongly influenced by demand-side factors (Foster, Haltiwanger and Syverson, 2016[41]). Beyond the role of demand for productivity itself, demand may also matter for the response of employment to technology-induced changes in productivity. On this aspect, Bessen (2019[42]) discusses a potential inverse-U shape of the employment effect of technology over time, which may emerge due to the elasticity of demand declining with technological progress over time.[5]

Building upon the analyses discussed above, this work contributes to the academic and policy debate by investigating directly the link between productivity growth and labour demand (focusing mainly on the dynamics of employment and wages) and characterising the heterogeneity of this relationship. It does so exploiting unique micro-aggregated harmonised representative data that allow studying the link between productivity growth and labour demand in detail, focusing on within-firm relationships for a large number of countries, but also inferring on relationships at more aggregate levels using the same data. This allows to investigate with unprecedented detail the role of compensation mechanisms and dynamics occurring at different aggregation levels, also accounting for the dynamic nature of the relationship between productivity growth and changes in labour demand.

3 Data

This section presents the MultiProd data used for the analysis. It provides information on the data collection and the coverage and further discusses measures of employment and productivity, as well as the granularity of the information available.

The analysis relies on harmonised and highly representative cross-country data on productivity from the OECD MultiProd project, which analyses the micro-drivers of aggregate productivity growth. The implementation of the MultiProd project is based on a standardised Stata routine that micro-aggregates confidential firm-level data from production surveys and business registers, via a distributed microdata approach. The distributed microdata approach involves running a common code in a decentralised manner by representatives in national statistical agencies or experts in governments or public institutions who have access to the national micro-level data. The centrally designed, but locally executed, statistical routines generate micro-aggregated data which are the basis of this analysis.

The MultiProd program relies on two main data sources in each country. First, it uses administrative data or production surveys (PS), which contain all the variables needed for the analysis of productivity, but which may be limited to a sample of firms. Second, it exploits business registers (BR) that typically cover the entire population of firms, but for a more limited set of variables.[6,7]

This analysis includes 13 countries (12 OECD Members – Belgium, Canada, Chile, Finland, France, Hungary, Italy, Japan, Latvia, the Netherlands, Portugal, Sweden – and one Accession country, Croatia) and focuses on manufacturing and non-financial market services. The (unbalanced) data cover the period 2000-2018, as detailed in Table 3.1.

To proxy for productivity, this analysis relies on a measure of multifactor productivity (MFP) estimated following the Wooldridge (2009[43]) control function approach, with value added as a measure of output and two inputs (capital and labour). This methodology assumes that firms have a Cobb-Douglas production function, flexibly allows for non-constant returns to scale and yields consistent standard errors. MFP measures in MultiProd are based on production functions estimated at the country-industry level, thus taking into account technological differences across countries and industries. By accounting for the levels of both capital and labour used by firms, MFP offers a more precise view of the efficiency with which firms use their inputs of production compared to simpler measures such as labour productivity. This may be key especially in the context of the analysis of employment implications of productivity growth if productivity changes are sometimes associated with changes in the capital-labour ratio. Note that the measure of multifactor productivity used in this report measures *revenue-productivity* (theoretically given by the product of physical productivity and prices). This is a common feature of analyses on productivity, given the lack of availability of firm-level prices in many datasets. This implies that the measure of changes in multifactor productivity may also be affected by demand-side factors and shocks affecting prices, on top of technological factors affecting the production function.

Table 3.1. Data coverage

Country	Period covered	Sectors covered	Industry-level data available	Transition matrix available
Belgium	2002-2018	Manuf. & services	Yes	Yes
Canada	2000-2018	Manuf. & services	Yes	No
Chile	2005-2016	Manuf. & services	Yes	No
Croatia	2002-2018	Manuf. & services	Yes	Yes
Finland	2000-2018	Manuf. & services	Yes	No
France	2000-2015	Manuf. & services	Yes	No
Hungary	2000-2018	Manuf. & services	Yes	Yes
Italy	2001-2015	Manuf. & services	Yes	Yes
Japan	2000-2015	Manuf.	Yes	Yes
Latvia	2007-2015	Manuf. & services	Yes	Yes
Netherlands	2001-2018	Manuf. & services	Yes	Yes
Portugal	2004-2017	Manuf. & services	Yes*	Yes
Sweden	2007-2018	Manuf. & services	Yes	Yes

Note: This table presents the coverage of the MultiProd data used for this analysis. “Manuf.” refers to manufacturing sectors and “services” refer to non-financial market services. Statistics in transition matrix data are available for the following (initial) years: 2001, 2004, 2007, 2008, 2009, 2010, 2012, 2015. *Data on aggregate productivity, used in the main industry-level regressions, are not available for Portugal.
Source: OECD MultiProd 2.0 database

Firm-level employment is directly measured in the microdata as the number of persons engaged or employees. Employment changes at the firm level are measured as log-changes and averaged across firms within cells. Total employment is also aggregated at the industry level to compute log-changes of total industry employment.

MultiProd aggregates firm-level data into micro-aggregated moments, at different levels of granularity. Firstly, this work leverages data on transitions of firms between productivity quantile groups (henceforth “transition matrix”) in each country, SNA A38 industry and year.[8] Secondly, the analysis exploits data aggregated at the country, industry and year. Table 1 above provides additional details on coverage and availability of these main datasets, which are further presented below.

In the transition matrix data, statistics are computed for cells defined at a highly disaggregated level according to the country, year, SNA A38 industrie, firm productivity quantile group in *t* and *t+h* (with *t*=2001, 2004, 2007, 2008, 2009, 2010, 2012, 2015 and *h=3, 5, 7, 10, 14*), conditional on data availability.[9] This report mainly focuses on measures of average changes in productivity, employment and wages among firms in the cell. Results based on the transition matrix focus on all firms active at time *t* and *t+h* (*h=3, 5, 7, 10, 14*) with positive value added. The work leverages on these granular data to infer within-firm relationships between productivity growth and relevant outcomes, notably the dynamics of employment and wages.[10] These data allow to speak directly to the within-firm level as averages within each transition cell (composed of a country, industry, year and transition group) may be interpreted as referring to a firm representative of the transition group within the country-industry-year. Therefore, the population of firms in the country-industry-year can be represented by the collection of firms representing a transition group within it.

This work also relies on data aggregated at the SNA A38 sector level (henceforth “industry-level data”), in which cells are defined according to the country, year and SNA A38 industry. These data collect information on average MFP (either unweighted, or weighted by value-added to reflect aggregate productivity), as well as on average firm size and total employment, on wages and other relevant variables. Total employment is measured as the average number of employees at a firm within the industry, multiplied by the number of firms, and reflects the total level of workers employed in the country-industry in the given year. The industry-level data are based on all active firms, and enable to infer aggregate links between productivity, employment and wages.

In addition, the report further relies on other OECD data. It exploits data from the OECD DynEmp project to compute measures of reallocation.[11] It also relies on measures of: productivity growth at the global frontier from the ORBIS database; ICT intensity based on the work of Calvino et al. (2018[44]); AI and ICT patents retrieved from the OECD Patstat database; forward and backward linkages based on the OECD Inter-Country Input-Output database (ICIO).

Table 3.2. Summary statistics of data from transition matrices

Variable	Horizon h (for change t to t+h)	N	mean	sd
Change in productivity	1	19 384	0.0275	0.2911
Change in employment	5	19 900	0.0425	0.3261
Change in average wage	5	19 850	0.0299	0.4519

Note: The statistics refer to the distribution of the average (over firms within a given cell) firm-level log-change of multifactor productivity, employment or wages. All statistics are based on firms active at time *t* and *t+5*. Statistics are computed based on a sample including 9 countries (Belgium, Croatia, Hungary, Italy, Japan, Latvia, the Netherlands, Portugal, Sweden), 22 SNA A38 industries in manufacturing and non-financial market services, and detailed transition between five productivity groups.
Source: OECD MultiProd 2.0 database

Table 3.3. Summary statistics of industry-level data

Variable	Horizon h (for change t to t+h)	N	mean	sd
Change in productivity	1	2 715	0.0112	0.1424
Change in employment	5	2 965	0.0098	0.2045
Change in average wage	5	2 752	0.0616	0.1600

Note: The statistics refer to the distribution of the industry-level aggregate log-change of multifactor productivity, employment or wages. Statistics are computed based on a sample including 12 countries (Belgium, Canada, Chile, Croatia, Finland, France, Hungary, Italy, Japan, Latvia, the Netherlands, and Sweden), 22 SNA A38 industries in manufacturing and non-financial market services.
Source: OECD MultiProd 2.0 database

Table 3.2 and Table 3.3 present summary statistics for the key variables used in the analyses at, respectively, the within-firm level and the industry level. Employment and wages appear to be on a positive trend on average, both within firms and at the industry level. All variables exhibit significant dispersion relative to a modest mean, as shown by the standard deviation. Notably, from a comparison of standard deviations, it appears that at both the within-firm and the industry level, short-term productivity changes exhibit a similar degree of variation as the longer-term variation in the key variables to be explained (employment and wages).

4 Firm-level relationship

This section investigates the relationship between productivity growth and employment growth within firms, and further analyses how firm-level productivity growth relates to firm exit and changes in the average wage of firms.

It first presents the methodology aimed at assessing the extent to which changes in firm productivity are accompanied by employment growth, also accounting for dynamic adjustments. Subsequently, it presents the results, which first investigate how changes in employment are related to both the rate of productivity growth and the initial level of productivity at the firm. Subsequently, it focuses on the mechanisms determining this relationship, especially related to firm-level sales expansion in response to productivity growth. The section then turns to the heterogeneity of this relationship across firms, investigating in particular the role of firms' initial position in the within-industry productivity distribution, and the roles of technological intensity and market power. Finally, it studies the relationship between firms' productivity growth and wage growth on the one hand, and between firms' productivity growth and firm survival on the other one.

Methodology

This section exploits the MultiProd transition matrices output (further described in the previous section), which provides information at a very granular level on the average characteristics and dynamics of firms which transition from one part of the productivity distribution to another over various time horizons.[12] Observations therefore correspond to the average firm in a country, industry, year, and detailed productivity transition group.

The initial analysis relies on a model that estimates average differences in employment growth (from time *t* to *t+5*) across firms in different productivity groups at time *t* to provide insights on the link between employment growth and initial productivity. The model is then extended to investigate the direction and the strength of the relationship between changes in productivity from time *t* to *t+1,* and changes in employment over the period *t* to *t+5*. Additional details are described in Box 1 below.[13]

The analysis takes into account a wide range of possible unobserved confounding factors at the level of country-industry-year, including dynamics affecting all firms in the same country-industry-year alike. Controlling for these factors allows to investigate the role of productivity growth relative to other firms in the same country-industry-year. When investigating the link between productivity growth and employment growth, the analysis also accounts for systematic differences across firms that have a different position in the initial productivity distribution within their industry.

The analysis then extends further the initial model to analyse the dynamic response of employment to productivity growth over time, accounting for possible adjustment lags. The model allows to further take into account the persistence of employment and productivity growth (i.e., the correlation of employment and productivity growth with their past growth values, that is autocorrelation). This model relies on the estimation of "impulse response functions" (IRF, henceforth) and further alleviates concerns that productivity and employment growth may be simultaneously determined, or that the observed relationship may simply reflect unobserved dependence on past productivity and employment growth. Further details are provided in Box 2.[14]

The analysis of the relationship between productivity and its growth with changes in firm-level wages relies on models analogous to the ones presented in Box 1 and Box 2 but relying on changes in the average wage rather than employment as the outcome variable to be explained.

As a final step of the analysis of firm-level outcomes, the report focuses on whether productivity growth reduces a firm's risk of failure, that is, whether firms that grow in productivity are less likely to exit the market over the following period. It estimates the link between productivity growth and the probability of exit using a logistic regression, further described in Box 3.

Box 1. Methodology: firm-level relationship between productivity and employment growth

The report first investigates the link between initial productivity rank at time t and future employment growth (from t to $t+5$) by reporting the coefficients associated to the initial productivity groups fixed effects (γ_{q_0}), controlling for country-industry-year fixed effects (γ_{cjt}), which are aimed at accounting for confounding factors and common dynamics varying at the country-industry-year level. The model is specified as follows:

$$\Delta_5 y_{cjgt} = \boldsymbol{\gamma_{q_0}} + \theta y_{cjgt} + \gamma_{cjt} + \varepsilon_{cjt}$$

Equation 1

In the equation above c denotes a country, j an SNA A38 industry, g a productivity transition group, t a year. $\Delta_5 y_{cjgt}$ is the five-year forward looking (from t to $t+5$) average within-firm growth rates of outcome y (either employment or wage). y_{cjgt} denotes the level of the outcome y in the initial period t.

This specification is also the basis for the investigation of the link between productivity *growth* and employment growth, accounting for the role of initial productivity quantile already analysed with the model corresponding to Equation 1. The model is therefore extended to include productivity growth between time t to $t+1$, and additional controls. It is specified as follows:

$$\Delta_5 y_{cjgt} = \beta_0 + \boldsymbol{\beta_1} \Delta_1 a_{cjgt} + \delta \Delta_1 y_{cjgt} + \theta y_{cjgt} + \gamma_{cjt} + \gamma_{q_0} + \varepsilon_{cjt}$$

Equation 2

where $\Delta_1 a_{cjgt}$ is the one-year forward looking (from t to $t+1$) average within-firm growth rates of productivity a, for firms in country c, SNA A38 industry j, productivity transition group g, and year t. $\Delta_1 y_{cjgt}$ is the growth rate of outcome variable between t to $t+1$, included to alleviate concerns that the coefficient of interest (β_1) may be affected by productivity and the outcome being simultaneously determined.

This equation includes also fixed effects taking into account a wide range of possible unobserved confounding factors at the level of country-industry-year γ_{cjt}, including dynamics affecting all firms in the same country-industry-year. It therefore exploits productivity and employment variation across firms within the same country, industry, and year. Note that an initial estimation step includes instead a less restrictive set of fixed effects (country-industry and country-year). In this regression the initial productivity group fixed effects γ_{q_0} control for structural differences between low and high productive firms, but also for other characteristics varying systematically across productivity groups.

The main coefficient of interest is β_1. Given the set of controls, it measures the association between productivity growth between time t to $t+1$ and the relevant outcome (employment and wage growth between time $t+1$ and $t+5$), focusing on average changes occurring within firms. It reflects a partial correlation but this may not imply a causal relationship. An alternative model also focuses on the contemporaneous correlation between productivity growth from *t* to *t+5* and employment growth from *t* to *t+5* (results are not reported but findings are qualitatively similar, as mentioned in the results section). The main model corresponding to Equation 2 however is better suited to deal with simultaneity issues.

The regressions are weighted according to the representativeness of an observation within the country, based on inverse probability weights defined by the MultiProd procedure (Berlingieri et al., 2017[45]). All countries are weighted equally. Standard errors are clustered at the country-sector level.

The model is easily extended to analyse the heterogeneity of the relationship (i.e., differences in β_1) according to the initial position of firms in the productivity distribution, or across industries or countries, by interacting productivity growth with relevant continuous or categorical variables.

Box 2. Methodology: dynamic adjustments of employment growth

To investigate the dynamic adjustments of employment and to further account for the role of past productivity and employment growth, the report also presents results based on impulse response function models (IRF). The modelling strategy follows Autor and Salomons (2018[2]), and implements a local projection estimation approach (Jordà, 2005[46]) to analyse how employment or wages respond at different time horizons to changes in productivity. More specifically, the model is extended to control simultaneously for past productivity growth, as well as for past growth in the outcome variable (i.e., either employment or wage growth), as follows:

$$y_{it+h} - y_{it-1} = \beta_0^h + \boldsymbol{\beta_1^h} \Delta a_{it} + \sum_{l=1}^{L} (\theta_{a,l}^h \Delta a_{it-l} + \theta_{y,l}^h \Delta y_{it-l}) + \gamma_{cjt}^h + \varepsilon_{it}^h \quad \text{Equation 3}$$

In Equation 3 above i denotes the panel unit, i.e., the country c, industry j, productivity transition group g, and γ_{cjt} denotes country-industry-year fixed effects (or in an initial estimation alternatively the country-industry and country-year fixed effects), that absorb specificities of the country-industry-year and the productivity and outcome dynamics common to firms in the same country-industry-year.

L denotes the lag order of the model, that is the number of lags of productivity and outcome growth that are allowed to affect current outcome growth. In the baseline specification, the model considers two-year productivity growth from t to $t+2$ as the impulse Δa_{it}, i.e., the main change of productivity under study, and controls for past productivity and outcome changes from $t-2$ to t, and $t-3$ to $t-2$. The choice of the timing is guided by data availability. The estimation of this model indeed relies on transition matrices, which collect information on the dynamics of firms at specific horizons (3, 5, 7, 10, and 14) to ease the preparation and sharing of data by participants to the MultiProd project. This imposes some constraints on the structure of the model.

The equation is separately estimated for individual horizons $h = 0,1,\ldots,H$ of interest, where H is the maximum horizon considered.

The main coefficient of interest is β_1^h, which measures the response of employment between $t-2$ and $t+h$ to an initial change in productivity between $t-2$ and t, while controlling for both past productivity growth and past employment growth.

Box 3. Methodology: the role of productivity for firm exit

The report also focuses on whether productivity growth reduces a firm's risk of failure, that is, whether firms that experience growing productivity are less likely to exit the market over the following period. To investigate this, the analysis relies on the estimation of a logistic regression model of the following form:

$$X^2_{cjt+5} = g(\beta^X_0 + \boldsymbol{\beta^X_1}\Delta_5 a_{cjgt} + \theta^X y_{cjgt} + \gamma^X_{cjt} + \gamma^X_{q_0}) + \varepsilon^X_{cjt}$$

Equation 4

In the equation above, X^2_{cjgt+5} is an indicator that is equal to one if g is a group that exits over the two years after $t+5$, i.e., between $t+5$ and $t+7$, and equal to zero otherwise. $\Delta_5 a_{cjgt}$ is the 5-year productivity change from t to $t+5$, and y_{cjgt} denotes the initial average employment in the cell cjg at time t.

The tables report average partial effects of productivity growth, the average of the partial derivative of $g(\beta^X_0 + \boldsymbol{\beta^X_1}\Delta_5 a_{cjgt} + \theta^X y_{cjgt} + \gamma^X_{cjt} + \gamma^X_{q_0})$ with respect to productivity growth across observations in the data.

Results

This sub-section presents the results of the analysis focusing on firm-level outcomes. It first shows that employment growth is higher for firms at the productivity frontier, and those close to the frontier. It then provides evidence that stronger productivity growth tends to translate into higher employment growth at the firm level, and that this may be particularly related to an increase in sales. It further shows that employment fully adjusts to productivity changes with a lag, and that the link between productivity growth and employment is heterogeneous across different groups of firms, operating in different industries or countries. It uncovers in particular a role of firms' initial position in the within-industry productivity distribution, as well as the industry-level intensity of ICT investments and differences in markups within industries. Finally, it highlights that a positive link emerges also between productivity growth and the growth of wages, and that higher productivity reduces the probability of firm exit.

Initial evidence: most productive firms have stronger employment growth

Columns 1 and 2 of Table 4.1 present the results of the estimation of Equation 1 to investigate differences in average employment growth between firms in groups with different initial productivity (i.e., between firms with a different starting point in terms of productivity ranking with respect to firms in the same country-industry-year). The second to fifth rows show the average difference in employment growth for each productivity group relative to the reference group composed of firms in the middle of the productivity distribution, while controlling for the initial size of firms across groups (seventh row).[15]

Results in columns 1 and 2 show that firms initially at the top of the productivity distribution display on average higher employment growth than other firms in the same country-industry-year.[16] Both frontier firms (labelled "Initial productivity group p90-p100" in the table) and firms closer to the frontier ("Initial productivity group p60-p90") display higher employment growth over the next five years relative to the reference median category. This suggests that high-productivity firms contribute importantly to employment dynamics.

Table 4.1. The firm-level link between productivity growth and employment growth: partial correlations

	(1)	(2)	(3)	(4)
	5-year change in employment	5-year change in employment	5-year change in employment	5-year change in employment
1-year change in productivity			0.135***	0.134***
			(0.0300)	(0.0334)
Initial productivity group p0-p10	0.0342**	0.0359**	0.0175	0.0214*
	(0.0138)	(0.0144)	(0.0117)	(0.0125)
Initial productivity group p10-p40	-0.0164***	-0.0157**	0.0000	0.00211
	(0.00599)	(0.00616)	(0.00400)	(0.00399)
Initial productivity group p60-p90	0.0429***	0.0423***	0.0227***	0.0207***
	(0.00405)	(0.00429)	(0.00321)	(0.00338)
Initial productivity group p90-p100	0.126***	0.125***	0.0696***	0.0646***
	(0.00950)	(0.0101)	(0.00773)	(0.00808)
1-year change in employment			1.777***	1.824***
			(0.0804)	(0.0842)
Initial employment	-0.00885	-0.00568	0.00371	0.00951
	(0.00901)	(0.0101)	(0.00628)	(0.00653)
Observations	19,900	19,875	19,384	19,356
R-squared	0.398	0.457	0.571	0.617
Fixed effects	C-I C-Y	C-I-Y	C-I C-Y	C-I-Y

Note: Estimates obtained from the models in Equation 1 (columns 1 and 2) and Equation 2 (columns 3 and 4). The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 9 countries (Belgium, Croatia, Hungary, Italy, Japan, Latvia, the Netherlands, Portugal and Sweden). Observations are weighted by the number of firms represented in the full population, normalised at the country level. C-I and C-Y indicate fixed effects for the country-industry and country-year, respectively, and C-I-Y indicate fixed effects for the country-industry-year. Standard errors given in parentheses are clustered at the country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

Productivity growth is positively associated with employment changes at the firm level

While initial productivity is strongly associated with employment growth, the *evolution* of firms' productivity is also and relevantly related to subsequent employment growth. More specifically, firms that experience stronger productivity growth than other firms in the same country-industry-year also have on average stronger employment growth.[17] This means that all else equal, firms that increase their productivity more also tend to increase more their size in terms of employment relative to competitors.[18]

This is shown in columns 3 and 4 of Table 4.1, which show a positive and statistically significant correlation between productivity growth over one year (from *t* to *t+1*, "1-year change in productivity" in the table) and employment growth over five years (from *t* to *t+5*).[19] This result accounts for firms' initial position in the productivity distribution and for their contemporaneous one-year employment growth ("1-year change in employment" in the table), together with additional unobserved factors affecting employment and productivity in all firms operating in a given country and industry for any given year. This finding is robust to a series of alternative specifications and robustness checks, such as adopting a less restrictive sets of fixed effects, changing the structure of the time lags considered, or taking into account the role of additional confounding factors that are observed only in some countries.[20]

This result echoes the finding of Baily, Bartelsman and Haltiwanger (1996[11]) for US manufacturing, challenging the "myth" that firm-level productivity growth is associated with downsizing. They conclude that productivity growth is also associated with upsizing for a significant share of firms, suggesting that productivity and employment growth may also be positively related at the firm level. The results presented in Table 4.1 complement this finding and show that for the period considered (2000-2018) higher productivity growth is on average associated with faster subsequent employment growth within the countries and industries considered.

The results presented in Table 4.1 also suggest that productivity changes relative to firms in the same country-industry-year, and against which they may be competing for market shares, may matter more than the magnitude of the productivity change *per se.* In other words, the positive link between employment and productivity growth identified in column 4 of Table 4.1 reflects dynamics *relative* to other firms in the same country, industry, and year. This suggests that a positive deviation of a firm's productivity growth from the productivity dynamics common to all firms in the same country-industry-year, and to all firms with the same initial level of productivity, is associated with faster employment growth.

This point already emerges from the comparison of columns 3 and 4 of Table 4.1. The result of column 3, which uses a less restrictive fixed effects structure allowing for other changes in productivity than those relative to competitors, shows an estimate for the coefficient of productivity growth very similar to the one in column 4.[21] Additional discussion on the importance of relative improvements in productivity will be carried out in the next subsection.

Table 4.2. The firm-level link between productivity growth and sales growth

	(1) 5-year change in employment	(2) 5-year change in sales
1-year change in productivity	-0.125**	1.633***
	(0.0544)	(0.374)
5-year change in sales	0.161***	
	(0.0186)	
1-year change in employment	1.516***	1.681***
	(0.0875)	(0.270)
Initial employment	-0.0312***	
	(0.00867)	
Initial sales		0.162***
		(0.0267)
Observations	19,355	19,355
R-squared	0.697	0.565
Fixed effects	C-I-Y G	C-I-Y G

Note: Estimates obtained from modifications of the model in Equation 2. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 9 countries (Belgium, Croatia, Hungary, Italy, Japan, Latvia, the Netherlands, Portugal and Sweden). Observations are weighted by the number of firms represented in the full population, normalised at the country level. C-I-Y indicate fixed effects for the country-industry-year, and G indicate fixed effects for the initial productivity group. Standard errors given in parentheses are clustered at the country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

The faster employment growth following an initial increase in productivity relative to other firms may be induced by an increase in demand experienced by firms that increase their productivity. Firms that become more efficient relative to others (regardless of the specific drivers of this change) may be able to charge lower prices, and therefore attract customers and increase sales, which in turn induce a higher demand for all factors of production, including labour.

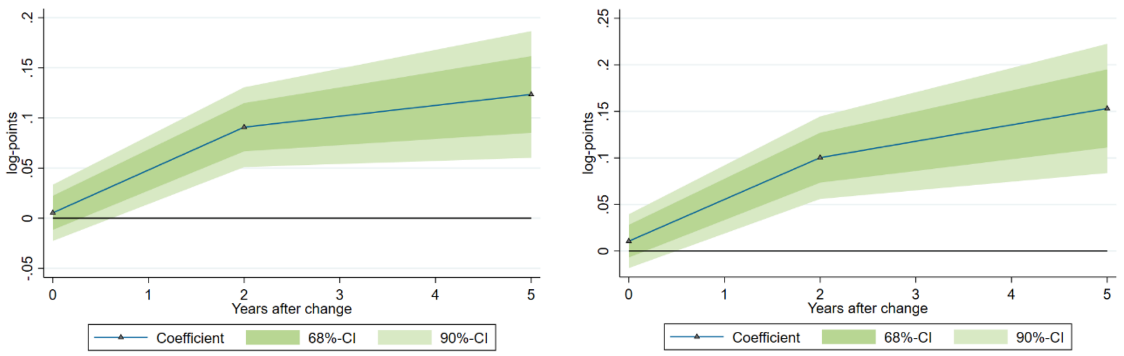
The role of increasing sales in driving the positive link between relative productivity growth and labour demand is confirmed by the results displayed in column 1 of Table 4.2. Once one accounts for the role of contemporaneous changes in gross output over a five-year period (“5-year change in sales” in the table), the link between productivity growth and employment growth becomes negative. This result may stem from two complementary mechanisms. First, an “efficiency effect”, whereby increasing productivity implies that the same output can be produced more efficiently and hence with less factors of production, including labour. Second, a “displacement effect”, that is when capital takes over tasks previously performed by labour, which may negatively affect labour demand in instances where productivity is driven by labour-saving technologies (Acemoglu and Restrepo, 2019[28]).

The previously discussed positive average association between productivity growth and employment growth suggests that on average the potential efficiency and displacement mechanisms (which tend to reduce labour demand) seem to be outweighed by the indirect positive mechanism related to the relative increase in sales. Column 2 of Table 4.2 also confirms that output increases following an initial period of higher productivity growth, suggesting that firms outcompeting others in terms of productivity experience relatively higher growth of sales.

Focusing on the results arising from the estimation of the dynamic “impulse response” model (see Equation 4 and details in Box 2), Figure 4.1 confirms the positive response of employment growth to changes in productivity. It further shows that employment may fully respond to initial changes in productivity only with a time lag. The estimates indeed suggest that there is limited contemporaneous adjustment during the same period over which the two-year productivity change occurs (as shown by the response at zero years after change, which is close to zero).

Hence, firms may take time to respond to changes in productivity and in their performance relative to competitors.[22] While the bulk of the subsequent adjustment occurs over the first two years after the productivity change, the point estimates suggest that employment may further continue to increase over the whole five-year period considered. The response depicted in Figure 4.1 shows that employment increases over the five-years period and is not reverted at the end of the period (i.e., employment does not revert to the initial level but stays persistently higher over the horizon considered). This suggests that faster productivity gains relative to other firms may induce a persistent change in size.

Figure 4.1. The firm-level link between productivity growth and employment growth: impulse response



(a) *Country-Industry Country-Year Fixed Effects* (b) *Country-Industry-Year Fixed Effects*

Note: This figure illustrates the results of the local projection impulse response regression estimations for the response of employment to a change in productivity using fixed effects for the country-industry and country-year (left) and fixed effects for the country-industry-year (right), based on Equation 4. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 9 countries (Belgium, Croatia, Hungary, Italy, Japan, Latvia, the Netherlands, Portugal and Sweden). Observations are weighted by the number of firms represented in the full population, normalised at the country level. Confidence bands are based on pointwise estimation of standard errors, clustered at the country-industry level.
Source: Authors’ calculations based on the OECD MultiProd 2.0 Database

Exploring the heterogeneity of the firm-level link

Beyond the average relationship discussed above, the link between productivity growth and employment growth appears heterogeneous across different groups of firms, operating in different industries or countries. First, improvements in relative productivity are more strongly associated with employment growth for non-frontier firms. Second, the link varies according to differences in market power across firms. Third, in an environment characterised by more innovation or the use of technologies with a stronger labour-saving potential the productivity-employment link is still positive, but to a lower extent. This heterogeneity in the dynamics of employment associated to productivity growth is further discussed below.

Firms closer to the frontier display higher employment growth on average (as discussed above and illustrated in Table 4.1), but non-frontier firms are more responsive to relative improvements in their productivity. This is illustrated in Table 4.3 below which shows the strength of the link for the baseline category (p0-p40) in the first row. It also shows the difference, with respect to this baseline, for frontier firms ("Initial productivity group = p90-p100") which display a positive but lower correlation between productivity and employment growth, and for non-frontier non-laggards firms ("Initial productivity group = p40-p90") which display a similar correlation as the reference category.[23] Figure A A.1. (based on the dynamic IRF model) in the Appendix also confirms a lower responsiveness of frontier firms relative to non-frontier firms.[24]

Table 4.3. The role of a firm's initial position for the firm-level link between productivity growth and employment growth

	(1)
	5-year change in employment
1-year change in productivity (baseline =p0-p40)	0.148***
	(0.0263)
* Initial productivity group = p40-p90	0.0207
	(0.0278)
* Initial productivity group = p90-p100	-0.0821***
	(0.0237)
1-year change in employment	1.808***
	(0.0854)
Initial employment	0.00981
	(0.00661)
Observations	19,356
R-squared	0.618
Fixed effects	C-I-Y G

Note: Estimates obtained from a heterogeneous effects extension of the model in Equation 2. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 9 countries (Belgium, Croatia, Hungary, Italy, Japan, Latvia, the Netherlands, Portugal and Sweden). Observations are weighted by the number of firms represented in the full population, normalised at the country level. C-I-Y indicate fixed effects for the country-industry-year, and G indicate fixed effects for the initial productivity group. Standard errors given in parentheses are clustered at the country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

Efficiency gains in non-frontier firms may allow them to strengthen an initially weaker position on the market, thereby attracting customers and increasing sales. On the contrary, firms at the frontier may have already reached higher levels of efficiency (through the adoption of new technologies, good management and organisational practices, investment in human capital, etc.), and may have already built a more stable customer base, allowing them to scale up regardless of further productivity improvements. For such firms, further relative improvements in productivity may therefore be less relevant for future employment. This also suggests that employment in more productive firms may be more resilient to negative productivity shocks (whether they arise from negative technology or revenue shocks), while initially less productive firms may be affected more strongly by such negative shocks.

A second source of heterogeneity in the strength of the productivity-employment growth nexus is related to the use of technologies with a higher potential for labour displacement. Recent waves of innovation in information and communication technologies (ICTs) and their broad diffusion have increased the scope of tasks that can be performed by capital instead of workers, contributing to the displacement of labour from some tasks. This phenomenon may partially offset some of the positive implications of productivity for employment that occur through the expansion of output. When task-replacing technologies are used, any given output target may indeed be achieved with less intense use of labour.

Table 4.4. The role of structural determinants for the firm-level link between productivity growth and employment growth

	(1)	(2)	(3)	(4)	(5)
	5-year change in employment	5-year change in employment	5-year change in employment	5-year change in employment	5-year change in employment
1-year change in productivity	0.144***	0.125***	0.121***	0.123***	0.131***
	(0.0318)	(0.0311)	(0.0349)	(0.0369)	(0.0348)
* ICT investment intensity	-0.0117***				-0.00817**
	(0.00425)				(0.00373)
* AI patenting intensity		-0.0344**			
		(0.0144)			
* ICT patenting intensity			-0.709**		
			(0.319)		
* Difference p90-p50 of markups				-0.0246***	-0.0223***
				(0.00534)	(0.00518)
1-year change in employment	1.811***	1.920***	1.917***	1.788***	1.782***
	(0.0834)	(0.0982)	(0.0966)	(0.0808)	(0.0810)
Initial employment	0.0103	0.0170**	0.0178**	0.0134**	0.0136**
	(0.00648)	(0.00691)	(0.00690)	(0.00658)	(0.00657)
Observations	19,356	15,222	15,222	19,832	19,317
R-squared	0.619	0.624	0.624	0.517	0.622
Fixed effects	C-I-Y G	C-I-Y G	C-I-Y G	C-I-Y G	C-I-Y G
Countries excluded	-	HRV, JPN	HRV, JPN	-	-

Note: Estimates obtained from heterogeneous effects extensions of the model in Equation 2.The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 9 countries (Belgium, Croatia, Hungary, Italy, Japan, Latvia, the Netherlands, Portugal and Sweden). Observations are weighted by the number of firms represented in the full population, normalised at the country level. C-I-Y indicate fixed effects for the country-industry-year, and G indicate fixed effects for the initial productivity group. Standard errors given in parentheses are clustered at country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

Column 1 of Table 4.4 shows indeed that employment is less strongly associated to relative changes in productivity in industries that use ICTs (which may have a higher potential to automate some tasks) more intensively.[25] Focusing on country-level proxies for innovation, columns 2 and 3 show that the relation appears weaker in country-years in which ICT and AI patent intensities are higher.[26] This suggests that productivity gains associated to a more intensive use of ICTs – or to higher innovation – may be associated to positive employment growth but to a lower extent if compared with productivity improvements related to firm-level changes that have a lower potential for task replacement.[27]

The competitive environment in which firms operate is another source of heterogeneity for the employment dynamics associated with relative productivity growth. To study this, the analysis investigates how the dispersion in market power (proxied by markups) across firms affects the correlation between productivity and employment growth. This quantity is measured as the difference between high and median markups within a country-industry pair each year, where high markups are proxied by the 90th percentile of the within country-industry-year distribution of markups.[28]

A high dispersion of markups may indicate a low degree of contestability of markets. When markup dispersion is high, a small number of dominant firms may hold a strong position that allows them to charge high markups while most firms in the industry do not. The latter group of firms may not be able to compete for market shares in the same way they would in environments with less markup dispersion. Relevantly, studies show that markup dispersion has affected welfare through misallocation (see for instance Baqaee and Farhi (2019[47]), Edmond, Midrigan and Xu (2018[48]) Peters (2020[49])). This may further affect the productivity-employment link, as the opportunity of firms catching up in productivity to expand sales – and therefore employment – may be limited by the less contestable position of the market leaders.[29] Results in column 4 of Table 4.4 indeed show that the higher the difference in markup across firms, the lower the correlation between relative improvements in productivity and employment growth.[30]

The lower association between productivity and employment growth related to higher technological intensity on the one hand, and to higher markups dispersion on the other seem to capture different mechanisms. Column 5 of Table 4.4 reports the estimated coefficients of a regression including the interaction of productivity growth with both the markup gap measure and the ICT intensity measure. Both are associated with a lower link between employment and productivity growth.

The lower correlation in ICT-intensive sectors suggests that productivity growth related to some specific technologies with a higher scope for capital-labour substitution are positively associated to relative employment growth at the firm-level, but to a lesser extent than productivity growth related to other drivers of efficiency. This is in line with evidence of a displacement effect associated to technologies that automate some tasks (Acemoglu and Restrepo, 2019[28]).

On the contrary the lower association between productivity and employment growth when markup dispersion is higher may reflect barriers related to within-industry differences in market power. Firms with initially low productivity and less market power may indeed face obstacles to increase sales (and therefore employment) when catching up towards the frontier firms. Therefore, while ICTs represent a source of additional firm-level productivity growth that may still allow firms to grow in size, higher markup dispersion may limit the potential of firm-level improvements in productivity to generate employment.[31]

Productivity growth and other margins: wages and the risk of exit

The positive change in labour demand from firms with a relative change in productivity is also confirmed by the comparative evolution of their wages (column 1 and 2 of Table 4.5). Firms with higher productivity growth also increase wages more than other firms. This holds after accounting for a wide range of unobserved confounding factors, similarly to the previous estimations. This result complements findings by Berlingieri et al. (2018[50]) of a robust productivity-wage premium. This change in wages may be related to firms sharing additional profits with workers, and to firms using wages as a tool to compete for workers on the labour market. Further, it may be linked to a change in the skill composition of workers, through the hiring of high-skill workers to fill new occupations, but also through a skill-shift within occupations (Bessen, Denk and Meng, 2022[51]).

Like the link with employment growth, the role of relative improvements against the competition within the country-industry seem to fully account for the observed relationship of productivity growth with wage growth. This is indicated by the result in column 2 of Table 4.5, which estimates the relationship using a restrictive set of fixed effects that does not allow for further improvements in productivity beyond those relative to competitors, and shows a similar coefficient for productivity growth to the one in column 1.

Table 4.5. The firm-level link between productivity growth and wage growth

	(1)	(2)
	5-year change in av. wage	5-year change in av. wage
1-year change in productivity	0.399***	0.429***
	(0.114)	(0.132)
1-year change in av. wage	2.248***	2.341***
	(0.260)	(0.290)
Initial av. wage	0.0511	0.0737*
	(0.0319)	(0.0381)
Observations	19,324	19,296
R-squared	0.639	0.668
Fixed effects	C-I C-Y G	C-I-Y G

Note: Estimates obtained from the model in Equation 2. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 9 countries (Belgium, Croatia, Hungary, Italy, Japan, Latvia, the Netherlands, Portugal and Sweden). Observations are weighted by the number of firms represented in the full population, normalised at the country level. C-I-Y indicate fixed effects for the country-industry-year, and G indicate fixed effects for the initial productivity group. Standard errors given in parentheses are clustered at the country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

Higher productivity growth also affects firms' employment through an extensive margin, as higher level of productivity and productivity growth are associated with a lower probability of firm exit. This is shown in Table 4.6 which estimates how productivity growth over five years is related to the risk of exit over the next two years.[32]

This indicates a selection mechanism, whereby less productive firms that fail to improve productivity are exiting the market. This selection of more productive firms, and firms which improve their productivity more, contributes to the reallocation of resources towards better performing firms. However, this also suggests that more rapid productivity improvements in some firms may negatively affect other firms as they may deteriorate their relative performance, and thereby increase their probability of exit. While this mechanism may be beneficial overall for the economy and is tightly linked to the productivity-enhancing reallocation process, this may also contribute to higher gross job destruction at the industry level (some of which may be compensated by gross job creation in expanding and more productive firms). The next section returns to this issue and presents results that suggest the productivity-induced reallocation process to be a net positive force for the productivity-employment link.

Furthermore, this result indicates that it may be key for non-frontier firms to at least keep up with the most productive firms in order to avoid the worker-side cost of job destruction associated with firm exit. This suggests that policies aimed at supporting broad technology diffusion may have relevant benefits for employment also through this extensive margin.

Table 4.6. Firm-level productivity growth and the risk of exit

	Exit (over 2 years)
5-year change in productivity	-0.189***
	(0.0262)
Initial employment	-0.101***
	(0.0258)
Observations	13,486
Fixed effects	C-I-Y G

Note: Estimates report average partial effects and are obtained from the logistic regression model in Equation 4. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 7 countries (Belgium, Italy, Japan, Latvia, the Netherlands, Portugal and Sweden). Observations are weighted by the number of firms represented in the full population, normalised at the country level. C-I-Y indicate fixed effects for the country-industry-year, and G indicates fixed effects for the initial productivity group. Standard errors given in parentheses are clustered at the country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

To sum up, focusing on within-firm employment growth over five years, results highlight a positive average association of productivity growth with subsequent employment changes. Notably, firms that are initially more productive and non-frontier firms that improve their productivity relative to competitors experience stronger and sustained employment growth. This positive link likely reflects indirect effects on employment channelled through increases in sales, which appear to outweigh direct negative effects related to efficiency and labour replacement (i.e., respectively the fact that less inputs are required to produce a given level of output, and the fact that productivity growth may reflect labour saving technological change). The stronger correlation for non-frontier firms likely reflects an employment growth potential that materialises when these firms strengthen their market position relative to competitors. Such correlation is dampened by differences in market power across firms and is also lower when labour-saving technology are more prevalent. Finally, productivity growth is also positively and relevantly associated with wage growth and firm survival.

5 Industry-level relationship and aggregate mechanisms

After uncovering a positive firm-level relationship between productivity growth and employment growth, the report investigates the relationship at a more aggregate level. Certainly, the firm-level responsiveness of employment to productivity changes is a key component of the industry-level relationship; however, aggregate dynamics are also shaped by additional mechanisms.

Indeed, a positive relationship at the firm level may not necessarily mean that productivity growth translates into employment growth at more aggregate levels. When looking beyond the firm-level mechanisms, reallocation mechanisms need to be accounted for: an increase in employment at some firms may indeed come at the expense of a reduction in employment at other firms, such as those losing their competitiveness or exiting the market. Thus, within-industry employment outcomes in response to productivity changes are more ambiguous.

The extent to which productivity growth results in net job creation at the more aggregate level may further depend on changes in demand at the industry level, and the importance of a labour-saving mechanism induced by some technologies. Moreover, industries do not operate in isolation, but are interlinked into global value chains. Productivity changes in one industry are therefore likely to spill over into employment changes also in other industries.

This section investigates the relevance of these mechanisms, focusing on aggregate industry-level changes in employment and productivity. Specifically, beyond studying the average industry-level relationship between these quantities, it analyses the reallocation mechanism associated with heterogeneous firm-level productivity growth, as well as the role of different factors possibly shaping the industry-level nexus, namely technology, demand and differences in market power. Finally, it turns to the spillovers in terms of employment outcomes that productivity growth may have on connected industries.

Methodology

The study turns to analysing the relationship of productivity growth and employment growth (and related outcomes, especially wages) at the level of a given industry within a country, assessing the extent to which the firm-level mechanisms translate into a similar relationship at the industry level. Accordingly, on the one hand the analysis focuses on industry level "totals", namely total employment at the industry level, and on the other hand focuses on the wage of the average worker in the industry.

Conceptually, the estimation strategy is very similar to the one adopted at the firm level. As an initial step towards understanding the industry-level link between productivity growth and employment growth, the analysis relies again on a model of partial correlations between short-term productivity changes (between time t and $t+1$) and long-term employment changes (between time t and $t+5$), taking into account the role of the short-term changes in employment co-occurring with the productivity change (from time t to $t+1$). It also accounts for variables proxying for the initial size and productivity level of the industry, as well as dynamics common to each industry across countries and those specific to each country-year.

In a second step, complementary evidence is again obtained from the estimation of the “impulse response” model that allows to further understand the dynamics over time. Relative to the partial correlations model, the impulse response model further alleviates concerns related to serial dependence of key quantities as it accounts for these patterns in a more comprehensive way (i.e., by taking into account a series of lagged changes in both productivity and employment). Box 4 explains in detail the methodology adopted for the core industry-level analysis.

To test if productivity changes in one industry spill over into employment changes also in other industries, the analysis relies on a distinct estimation approach, which builds on Autor and Salomons (2018[2]).

The analysis of value chain spillovers of productivity growth relies on a “distributed lag” model that takes into account lagged effects of productivity on employment, accounting for the fact that adjustments may take time to fully materialise. In this model, a one-year change in employment in a given industry is explained by three sets of terms: (i) productivity growth of the industry itself, as in the previous part of the analysis *(own-industry productivity growth)*; (ii) productivity growth in either domestic or foreign industries that supply intermediate inputs to the considered industry *(supplier productivity growth)*; (iii) productivity growth in either domestic or foreign industries that consume outputs of the considered industry as intermediate inputs *(customer productivity growth)*. The measures used in the analysis account for indirect value chain connections and therefore also capture indirect spillovers arising from the network through input-output linkages.

Notably, as the framework considers a given industry, the role of productivity growth at supplier (customer) industries allows to address the presence and strength of downstream (upstream) spillovers of productivity growth along the value chain. Considering an industry which is downstream relative to its suppliers, the effect that productivity growth experienced by these suppliers may have on employment at the given industry is labelled as a *downstream* effect. On the contrary, spillovers that may arise from downstream customer industries on the considered upstream industry are labelled as *upstream* effect. Additional details on the estimation procedure are provided in Box 5.

Finally, the approach of Autor and Salomons (2018[2]) is further extended to account for spillovers arising from global value chains due to input-output linkages with foreign industries, accounting for the fact that productivity growth may matter for employment also across borders. Differently from Autor and Salomons who discuss value chain spillovers only in the context of productivity growth emerging from a common cross-country trend in (labour-replacing) technologies, this report continues to consider the measure of aggregate multifactor productivity as a proxy for general productive efficiency at the industry level. It therefore attempts to be more comprehensive in understanding how productivity growth originating from some industries may affect employment growth in the economy as a whole.

Box 4. Methodology for core industry-level analysis

In a first step, the analysis relies on the estimation of the partial correlation between an initial, short-term, change in productivity and the long-term change in employment or wage:

$$\Delta_5 y_{cjt} \;=\; \beta_0 + \boldsymbol{\beta_1}\Delta_1 a_{cjt} + \delta\Delta_1 y_{cjt} + \theta z_{cjt} + \gamma_{ct} + \gamma_j + \varepsilon_{cjt} \qquad \text{Equation 5}$$

Here, $\Delta_5 y_{cjt}$ denotes the change in the outcome y_{cjt} (i.e., total employment and average wage) of the country c, industry j from time t to $t+5$, $\Delta_1 a_{cjt}$ denotes the change in industry-level aggregate productivity in country c, industry j from time t to $t+1$, and $\Delta_1 y_{cjt}$ is the change in the outcome over the same period, i.e., from t to $t+1$. z_{cjt} are control variables capturing the initial state of the system, including the level of productivity and the outcome at time t. γ_{ct} and γ_j are fixed effects controlling for unobserved heterogeneity at the level of the country-year and the industry, respectively. Including these fixed effects allows to control for business cycle effects, country-level shocks, systematic differences across countries (also changing over time), as well as industry-specific trends. The model therefore focuses on deviations of productivity and employment growth from the dynamics common to all industries in a country, and across countries for a given industry.

The analysis further relies again on the impulse response of outcomes to an initial change in productivity, similarly to Box 2, where now, the subscript i refers to a country c, industry j. Due to the higher frequency of data available compared to the firm-level estimations, and considering that industry-level trends may be more persistent, the model includes four lags (that is $L = 4$).

In order to keep a sufficient number of observations, thereby preserving statistical power, the analysis is limited to a response of employment to a maximum horizon of three years after the initial "shock" (i.e., $H = 3$). This model is more suited to control for the correlation of employment and productivity growth with past growth (i.e., autocorrelation), and therefore may more precisely assess the link between employment (or wage) and productivity growth when autocorrelation may be a more relevant issue.

To further understand the role of different sources of productivity growth, an instrumental variable approach is applied to the model

$$\Delta_5 y_{cjt} \;=\; \beta_0 + \boldsymbol{\beta_1}\Delta_5 a_{cjt} + \theta z_{cjt} + \gamma_{ct} + \gamma_j + \varepsilon_{cjt} \qquad \text{Equation 6}$$

that regresses the five-year change in employment on the contemporaneous change in productivity. By instrumenting productivity growth with specific sources that are exogeneous to industry-level employment trends (detailed further below together with the results), this method allows to study directly the contemporaneous association of longer-term changes in productivity and employment in a fashion that further overcomes possible endogeneity concerns arising from the quantities being (possibly) simultaneously determined.

Regressions are weighted by the value-added share of a sector within a country-year, and countries are weighted equally. Standard errors are clustered at the country-industry level.

Box 5. Methodology for analysis of value chain spillovers

The analysis of value chain spillovers between industries estimates a distributed lag model of the form:

$$\Delta y_{jct} = \sum_{h=0}^{2}(\beta_h^{own}\Delta a_{jct-h} + \beta_h^{S}\Delta a_{jct-h}^{S} + \beta_h^{C}\Delta a_{jct-h}^{C} + \beta_h^{S,fgn}\Delta a_{jct-h}^{S,fgn} + \beta_h^{C,fgn}\Delta a_{jct-h}^{C,fgn}) + \gamma_j + \gamma_{ct} + \varepsilon_{jct} \qquad \text{Equation 7}$$

The outcome Δy_{jct} (either change in the total or average employment) of the industry j of country c in year t is modelled as a function of up to two lags of several terms capturing different changes in productivity, arising in the same industry *j*, or in supplier and customer industries, as detailed below.

The first term Δa_{jct}, as in the model in Box 4, is the change in industry-level aggregate productivity in the industry j. The terms Δa_{jct}^{S} and $\Delta a_{jct}^{S,fgn}$ are weighted averages of industry-level aggregate productivity growth in, respectively, domestic and foreign *supplier* industries (with weights based on the Leontief inverse matrix for value added indicating the strength of industry linkages). Specifically, $\Delta a_{jct}^{S} = \sum_{k\neq j} w_{kct}^{S,j}\,\Delta a_{kct}$ where $w_{kct}^{S,j}$ is the share of value added in industry j accounted for by the domestic industry $k \neq j$, and $\Delta a_{jct}^{S,fgn}$ is defined in analogy summing over non-domestic supplier industries.

Conversely, a_{jct}^{C} and $\Delta a_{jct}^{C,fgn}$ are weighted averages of industry-level aggregate productivity growth in, respectively, domestic and foreign customer industries. Here, $\Delta a_{jct}^{C} = \sum_{k\neq j} w_{kct}^{C,j}\,\Delta a_{kct}$ where $w_{kct}^{C,j}$ is the impact of production in industry *j* on final demand in the domestic industry $k \neq j$, and $\Delta a_{jct}^{C,fgn}$ is defined in analogy summing over non-domestic customer industries. All these variables are standardised in order to allow a more natural interpretation of coefficients. Finally, γ_j and γ_{ct} denote fixed effects for the industry and the country-year, respectively, and absorb the role of industry-specific trends and country-year specificities together with business cycle effects.

For each productivity term, the coefficient of interest is the sum of coefficients associated with the terms at different lags. This sum reflects the total impact of the productivity term on the outcome. The results presented directly estimate this sum by using that for each term Δa_{jct}^{T} with coefficients β_h^{T}, $h = 0,1,2$,

$$\beta_0^T\Delta a_{jct}^T + \beta_1^T\Delta a_{jct-1}^T + \beta_2^T\Delta a_{jct-2}^T = \left(\sum_{h=0}^{2}\beta_h^T\right)\Delta a_{jct}^T + \beta_1^T\left(\Delta a_{jct-1}^T - \Delta a_{jct}^T\right) + \beta_2^T\left(\Delta a_{jct-2}^T - \Delta a_{jct}^T\right).$$

Results

Industry-level employment growth is positively but weakly related to productivity growth

Focusing on industry-level quantities, results show that the association between productivity growth and employment growth remains positive, albeit weaker (both in terms of magnitude and significance) than what was found at the firm level.

This is evident both from Table 5.1, displaying results from the partial correlation model, and from Figure 5.1 illustrating the results from the dynamic IRF model.[33,34] The former reports a positive but not statistically significant association between changes in aggregate productivity and consequent changes in industry employment, net of other factors which are accounted for (as discussed in Box 4). The latter confirms this result by showing that in the IRF model the link between productivity growth and employment growth is positive, but only marginally significant.

This suggests that within a country and year, and after taking into account unobserved sector-specific confounding factors, industries that have higher productivity growth tend to have moderately higher employment growth, though the relation is only weakly significant in the dynamic IRF model.

Table 5.1. The industry-level link between productivity growth and employment growth: partial correlations

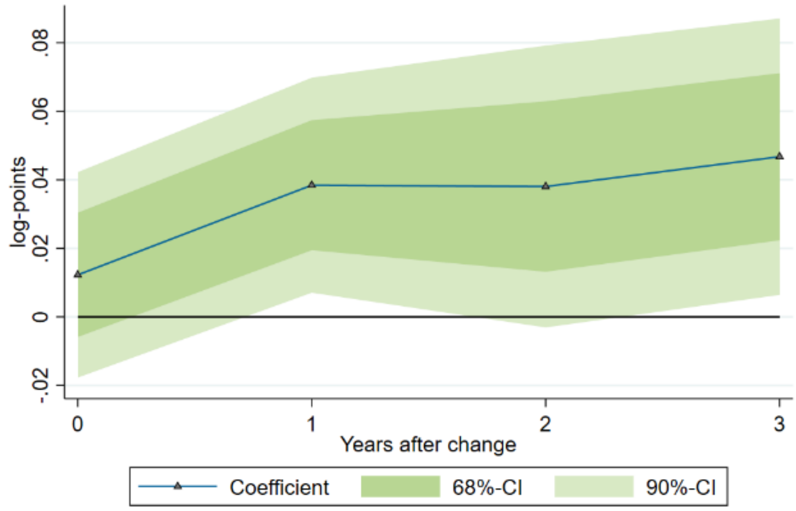
	(1)
	5-year change in employment
1-year change in aggregate productivity	0.0137
	(0.0193)
1-year change in total employment	1.248***
	(0.0754)
Initial total employment	-0.0742***
	(0.0150)
Initial aggregate productivity	0.00256
	(0.00546)
Observations	2,713
R-squared	0.674
Fixed effects	I C-Y

Note: Estimates obtained from the model in Equation 5. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 12 countries (Belgium, Canada, Chile, Croatia, Finland, France, Hungary, Italy, Japan, Latvia, the Netherlands, and Sweden). Observations weighted by the industry level aggregate of value added. I and C-Y indicate fixed effects for the industry and country-year, respectively. Standard errors given in parentheses are clustered at country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

This weaker relationship observed at the industry level may emerge as the gains of productivity-improving firms in terms of employment and sales may be in part negatively compensated at the industry level by reallocation mechanisms. Increasing employment in some firms – such as those catching up towards the top of the productivity distribution – may indeed come at the expenses of a reduction in employment for other firms – such as those losing their competitiveness or exiting the market – making the within-industry employment outcomes more ambiguous.

In fact, relative to the firm level, the industry-level relationship accounts for the net effects of the reallocation mechanism, whereby innovative firms expand market shares and employment at the expense of other less competitive firms that shrink or exit. This mechanism may result into less evident industry-level net employment gains associated to within-firm productivity growth. The evidence presented so far however suggests that the net effects are not negative but, if anything, weakly positive, in contrast with the idea that productivity changes may overall induce job losses at the industry level. The rest of the report refers to this mechanism as the *productivity-induced job reallocation* mechanism, which is explored in further detail in the next sub-section.

Figure 5.1. The industry-level link between productivity growth and employment growth: impulse response



Note: This figure illustrates the results of the local projection impulse response regression estimations for the industry-level response of total employment to a change in aggregate productivity, based on Equation 3. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 12 countries (Belgium, Canada, Chile, Croatia, Finland, France, Hungary, Italy, Japan, Latvia, the Netherlands, and Sweden). Observations are weighted by the industry level aggregate of value added, normalised at the country level. Confidence bands are based on pointwise estimation of standard errors, clustered at the country-industry level.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database.

The productivity-induced job reallocation process matters for industry-level employment growth

The previous subsection has shown that, also at the industry level, productivity growth is not negatively related to the dynamics of employment. This suggests that – on average – jobs created by productivity-improving firms tend to offer sufficient counterbalance to the negative changes in employment induced by shrinking and exiting firms.

Evidence about this productivity-induced job reallocation mechanism can be grasped more directly by focusing on the relationship between productivity growth dispersion – a direct measure of the coexistence of firms with diverse productivity growth patterns – and several measures related to job reallocation at the industry level.

The role of productivity growth dispersion at the industry level for job reallocation is illustrated in Table 5.2. Column 1 shows that dispersion (measured by the standard deviation) of one-year productivity growth rates is positively and significantly associated with dispersion of employment growth over the next five years. Columns 2 to 4 show the link between productivity growth heterogeneity and measures of job reallocation from the OECD DynEmp project.[35] A higher dispersion of productivity growth rates is associated with higher job reallocation, excess job reallocation, and excess job reallocation of incumbents.[36]

Columns 5 and 6 highlight that this process is related to both higher job creation and higher job destruction at the industry level. Unreported results (available upon request) suggest that the productivity growth gap between higher productivity growth firms and median growth firms generates reallocation through high job creation rates, but also to some extent through higher job destruction rates. This evidence is in line with the presence of the aforementioned productivity-induced job reallocation mechanism.

The reallocation process is key for aggregate productivity growth as it enables the reallocation of resources to more productive firms. Results presented below suggest that an efficient reallocation of resources may further be essential for employment dynamics at the industry level. On the contrary, factors that may slow it down may also imply a less positive (or possibly negative) response of industry-level employment growth to positive productivity shocks.

Table 5.2. The link between dispersion of productivity change and job reallocation

	(1)	(2)	(3)	(4)	(5)	(6)
	Standard-deviation 5-year empl. Growth	Average excess job reallocation over 5 years	Average excess job reallocation of incumbents over 5 years	Average job reallocation rate over 5 years	Average job creation rate over 5 years	Average job destruction rate over 5 years
Std one-year productivity change	0.0383**	3.8359**	2.4348**	5.1695**	2.7007***	2.6704**
	(0.019)	(1.612)	(0.979)	(2.006)	(0.946)	(1.314)
Initial employment	0.0037*	-0.7277*	-0.2847	-0.9525**	-0.6525**	-0.3140
	(0.002)	(0.387)	(0.203)	(0.426)	(0.256)	(0.202)
Lagged dependent variable	0.5402***	0.3211***	0.4602***	0.3274***	0.3151***	0.3104***
	(0.053)	(0.064)	(0.030)	(0.062)	(0.047)	(0.040)
Observations	2673	1585	1585	1585	1585	1585
Adj. R-Square	0.959	0.841	0.842	0.847	0.866	0.758
Fixed effects	I C-Y	I C-Y	I C-Y	I C-Y	I C-Y	I C-Y
Countries excluded	-	CHL, HRV, JPN	CHL, HRV, JPN	CHL, HRV, JPN	CHL, HRV, JPN	CHL, HRV, JPN

Note: Estimates obtained from an extension of the model in Equation 5, focusing on measures of productivity growth dispersion as the main regressor and measures of job reallocation as the main dependent variables. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services. The first column is based on a sample of 12 countries (Belgium, Canada, Chile, Croatia, Finland, France, Hungary, Italy, Japan, Latvia, the Netherlands, and Sweden) and columns 2 to 6 are based on a sample of 9 countries (Belgium, Canada, Finland, Hungary, Italy, Latvia, the Netherlands, Portugal and Sweden) available in both the MultiProd and DynEmp dataset. Observations are weighted by the industry level aggregate of value added, normalised at the country level. I and C-Y indicate fixed effects for the industry and country-year, respectively. Standard errors given in parentheses are clustered at the country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database and the OECD DynEmp v3 Database.

Results in columns 2 and 3 of Table 5.3. shows this using two complementary measures based on the difference in market power across firms, proxied by the gap between high and median markups (the measure in column 3 is continuous, and the one in column 2 is a binary variable classifying industries in high or low markup dispersion).[37] Both measures are associated with lower employment growth related to productivity changes, and high gaps in markups may therefore dampen the positive response of employment which may even become negative. As highlighted also in the previous section, the contestability of markets may be key in allowing growing firms to benefit from productivity gains by expanding sales, which may, however, be prevented if gaps in market power are large. This, in turn, may contribute to reduced job creation by firms with a high potential for growth.

At the industry level, this may distort the balance between non-frontier firms where productivity growth is net job creating on the one hand, and frontier firms where own-firm employment implications of productivity growth may be weaker than the induced job destruction at other firms in the same industry on the other hand. This may possibly explain the observed industry-level pattern in case of higher asymmetries in market power.

Table 5.3. The role of structural determinants for the industry-level link between productivity growth and employment growth

	(1)	(2)	(3)
	5-year change in employment	5-year change in employment	5-year change in employment
1-year change in productivity	0.0123	-0.00518	0.0129
	(0.0175)	(0.0149)	(0.0187)
* ICT investment intensity			0.000474
			(0.00362)
* Difference p90-p50 of markups	-0.0107***		-0.0110***
	(0.00322)		(0.00394)
* 1[high difference p90-p50 of markups]		-0.107***	
		(0.0266)	
Observations	1,966	1,998	1,966
R-squared	0.693	0.686	0.693
Fixed effects	I C-Y	I C-Y	I C-Y
Heterogeneity variable(s) controlled	yes	yes	yes
Countries excluded	CAN, CHL, FRA	CAN, CHL, FRA	CAN, CHL, FRA

Note: Estimates obtained from a heterogeneous effects extension of the model in Equation 5. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 12 countries (Belgium, Canada, Chile, Croatia, Finland, France, Hungary, Italy, Japan, Latvia, the Netherlands, and Sweden). Observations are weighted by the industry level aggregate of value added, normalised at the country level. I and C-Y indicate fixed effects for the industry and country-year, respectively. In analogy to the baseline model (cf. Table 4.1, Equation 5), the estimated models control the initial levels of aggregate productivity and employment, and the 1-year employment change occurring contemporaneously to the productivity change; coefficients are omitted from the table for brevity. Standard errors given in parentheses are clustered at the country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

Column 3 of Table 5.3. confirms that the measures of differences in markups used here capture a distinct association with respect to the one captured by the ICT intensity of industries. The coefficient for the differential relationship of productivity growth with employment growth according to the markup difference in industries (row 3) is virtually unchanged even when including the ICT intensity of the industry as a further heterogeneity variable. This distinction is important since ICTs are also structurally relevant for the productivity-employment nexus as shown before, and existing research shows that markups have been higher in ICT-intensive environments especially more recently (Calligaris, Criscuolo and Marcolin, 2018[52]).

The type of technology and the scope for increasing sales determine the strength of direct and indirect mechanisms

The responsiveness of employment to productivity is affected by the balance between a direct negative mechanism related to efficiency and labour replacement, and an indirect positive mechanism related to changes in demand through sales. While the previous section has investigated these mechanisms in detail at the firm level, their relevance at the industry level is now further investigated focusing on the different responses of employment to productivity when its change is driven by different factors.

Taken in isolation, the component of productivity growth more strongly related to automation and frontier technological progress tends to be negatively correlated with employment growth over the studied period, in which technological progress was significantly related to innovations allowing capital to perform workplace tasks. This is shown in column 1 of Table 5.4, in which productivity growth is proxied by productivity changes at the global frontier together with the change in AI patent intensity across countries and years (using the instrumental variable approach described in Equation 6 in Box 4).[38] This proxy based on the dynamics of the global frontier and of AI patenting aims at capturing the part of productivity growth which is driven to a larger extent by innovation in technologies with a stronger labour-saving component. The negative and significant coefficient of “5-year change in productivity” in column 1 indicates that these sources of productivity growth may be associated with a relatively slower employment growth at the industry level.[39] This relation does not however take into consideration other more labour-enhancing sources of productivity growth and the role of inter-industry linkages, which will be discussed in the next subsection.

Indeed, this more labour-saving source of productivity growth does not necessarily generate aggregate net job losses at the industry level if the compensating indirect mechanisms related to sales expansion are sufficiently strong. To this end, evidence suggests that productivity growth driven by factors more related to the possibility of a market expansion is indeed positively and significantly associated with employment growth. This is illustrated in column 2 of Table 5.4, which links employment growth with productivity growth related to a change in trade exposure – measured through the interaction of global value chain linkages and a country-year measure of change in trade exposure.

Table 5.4. The role of the source of productivity growth for the industry-level link between productivity growth and employment growth: instrumental variable estimates

	(1)	(2)
	5-year change in employment	5-year change in employment
5-year change in productivity	-0.206*	0.353***
	(0.106)	(0.134)
Initial employment	-0.0953***	-0.113***
	(0.0122)	(0.0141)
Initial aggregate productivity	-0.00556	0.0224***
	(0.00767)	(0.00829)
Observations	2,310	2,617
R-squared	0.389	0.358
IV	**innovation (AI/frontier)**	**change in trade exposure**
F stage 1	16.7	11.6
Fixed effects	I C-Y	I C-Y
Countries excluded	HRV, JPN	JPN

Note: Estimates obtained from the model in Equation 6. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 12 countries (Belgium, Canada, Chile, Croatia, Finland, France, Hungary, Italy, Japan, Latvia, the Netherlands, and Sweden). Observations are weighted by the industry level aggregate of value added, normalised at the country level. I and C-Y indicate fixed effects for the industry and country-year, respectively. Standard errors given in parentheses are clustered at the country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors’ calculations based on the OECD MultiProd 2.0 Database

The internationalisation of industries through higher exports and connection to global value chains may be associated with stronger productivity growth, through higher market selection and competition. At the same time, such productivity gains occur in a context in which firms may be able to expand sales through international trade, possibly overcoming limitations related to limited domestic market size and business stealing phenomena. Furthermore, as industries are interconnected through global value chains, efficiency gains in one industry may boost sales and employment in other industries. The role of globalisation through connection to value chains is explored further below.

Industry-level productivity growth also boosts wage growth

The analysis at the industry level has so far focused on the role productivity growth may play for employment. However, productivity growth may have an impact on labour markets and thereby welfare through its role for the quality of work in addition to the quantity of work. To this end, wages and in particular industry-level wage dynamics are an important proxy that are examined in this subsection.

The evidence indicates that productivity growth may lead to differentially positive changes in the wage of the average worker of the industry, and policies addressing the productivity slowdown may therefore also be able to address sluggish wage growth. As columns 2 and 3 of Table 5.5 show, both one-year and five-year productivity growth are positively associated with wage growth over the same period.

The estimates obtained from the main specification of the industry-level model in column 1 of Table 5.5, which controls for the change in wages occurring contemporaneously to productivity growth, instead does not show a positive association.

Table 5.5. The industry-level link between productivity growth and wage growth: partial correlations

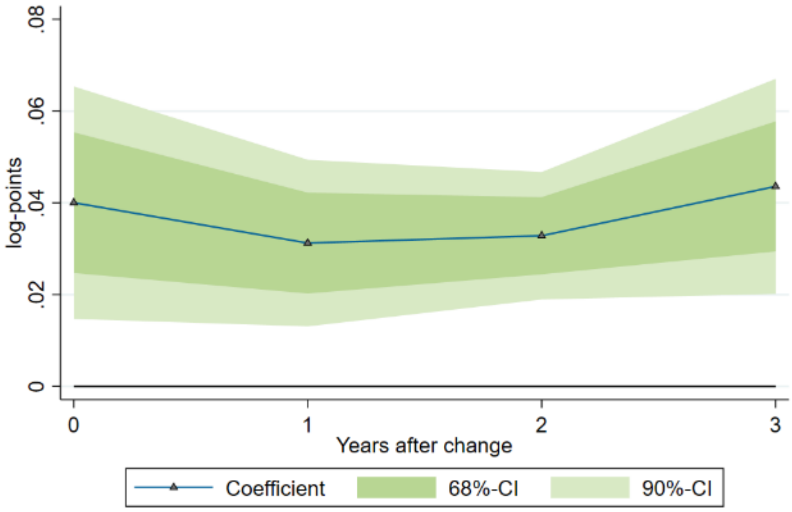
	(1)	(2)	(3)
	5-year change in av. wage	1-year change in av. wage	5-year change in av. wage
1-year change in aggregate productivity	0.00250	0.0487***	
	(0.00872)	(0.0165)	
5-year change in aggregate productivity			0.0312***
			(0.0100)
1-year change in av. worker wage	0.665***		
	(0.0432)		
Initial av. worker wage	-0.135***	-0.0321***	-0.154***
	(0.0144)	(0.00714)	(0.0164)
Initial aggregate productivity	0.00311	0.00183	0.00496
	(0.00294)	(0.00142)	(0.00384)
Observations	2,713	2,713	2,713
R-squared	0.899	0.957	0.879
Fixed effects	I C-Y	I C-Y	I C-Y

Note: Estimates obtained from the model in Equation 5 (column 1) and modifications thereof (columns 2 and 3). The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 12 countries (Belgium, Canada, Chile, Croatia, Finland, France, Hungary, Italy, Japan, Latvia, the Netherlands, and Sweden). Observations weighted by the industry level aggregate of value added. I and C-Y indicate fixed effects for the industry and country-year, respectively. Standard errors given in parentheses are clustered at the country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

Taken together, this evidence suggests that the association of wages with productivity growth is positive but, in contrast to the response of employment, it occurs in large part over the same period as the productivity change (i.e. it does not adjust with a lag). This is also confirmed by the dynamic impulse response model (Figure 5.2), which shows a contemporaneous response of wages to productivity, with persistent effects on wage levels over time.

The faster adjustment of wages relative to employment may be linked to different factors. First, productivity-improving firms may find it easier to increase wages than to increase employment in the short term, as labour market matching takes time. Second, and relatedly, wages may be used as a competitive tool that productivity-improving firms use to attract workers on the labour market, leading wages to adjust before employment is fully reallocated. Third, industry-level productivity growth may, to some extent, reflect the exit of low productivity, low wage firms. Finally, it could also reflect to some extent other factors such as the upskilling of the workforce, which also implies a change in the average wage due to higher wages earned by more qualified workers.

Figure 5.2. The industry-level link between productivity growth and wage growth: impulse response



Note: This figure illustrates the results of the local projection impulse response regression estimations for the industry-level response of total employment to a change in aggregate productivity, based on Equation 3. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 12 countries (Belgium, Canada, Chile, Croatia, Finland, France, Hungary, Italy, Japan, Latvia, the Netherlands, and Sweden). Observations are weighted by the industry level aggregate of value added, normalised at the country level. Confidence bands are based on pointwise estimation of standard errors, clustered at the country-industry level.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

Between-Industry and between-economy spillovers

Productivity growth in an industry (relative to other industries) appears to be only moderately related to relative employment growth within the same industry, as discussed in the previous sub-section. However, aggregate outcomes related to industries' productivity growth are not shaped only by the aggregation of industry outcomes, but also by the linkages of industries through value chains. These supplier-customer linkages may be a source of propagation of productivity spillovers on employment in connected industries.

Therefore, this section focuses on employment dynamics related to productivity growth in supplier and customer industries, i.e., industries for which, respectively, the originating industry is upstream or downstream in the production chain.[40] It uses data from the OECD Inter-Country Input-Output tables to measure the linkages among country-industry pairs available in the MultiProd database.

Results of the estimated model, presented in Table 5.6, provide evidence of downstream spillovers, as the positive and significant coefficients reported in the second and fourth row of Table 5.6 suggest. In other words, employment growth in a given industry is positively related to productivity growth in the supplier industries. The positive association is observed for both domestic and foreign suppliers, extending the results from Autor and Salomon (2018[2]) of spillovers arising from domestic suppliers. It is noteworthy that the magnitude of the downstream effect (as measured by the response to a standardised shock) is similar for productivity changes arising from domestic and foreign suppliers.[41] Comparing columns 1 and 2 of Table 5.6, the change in total industry-level employment induced by downstream value chain spillovers appears similar to the one in the average firm's size. This suggests that these spillovers occur by facilitating the growth of existing connected firms (rather than through an extensive margin).[42] [43]

This positive link between the productivity growth of supplier industries (domestic and foreign) and the employment growth in customer industries may be related to the change in intermediate prices associated to supplier productivity gains (Acemoglu, Akcigit and Kerr, 2016[53]). This may benefit customer industries and allow them to raise their sales, in turn inducing this downstream effects of productivity growth.

On the contrary, results suggest that there is no significant association between productivity growth in (both domestic and foreign) customer industries and employment growth in supplier industries. This is also in line with evidence by Autor and Salomons (2018[2]). Increased productivity in customer industries may not necessarily lead to higher demand of intermediates, as increasing sales resulting from lower prices may be partially compensated by higher efficiency, so that less input are required to produce the same level of output. Finally, in line with previous results on the own-industry relationship between productivity growth and changes in employment, the first row of Table 5.6 again identifies a positive but not statistically significant relationship between these two quantities.

Overall, the results suggest that productivity growth in upstream industries may contribute to higher aggregate employment growth, due to the existing links across industries along value chains. They also suggest that both domestic and foreign linkages may contribute to these spillovers across industries.

Table 5.6. Employment spillovers of industry-level productivity growth along the value chain

	(1)	(2)
	Change in total employment	Change in average employment
Change in own-industry productivity	0.0208	0.00532
	(0.0261)	(0.0170)
Change in domestic supplier productivity	0.00814**	0.00842**
	(0.00411)	(0.00363)
Change in domestic customer productivity	0.00172	-0.00109
	(0.00251)	(0.00195)
Change in foreign supplier productivity	0.0114**	0.0107**
	(0.00566)	(0.00420)
Change in foreign customer productivity	0.000393	0.00124
	(0.00297)	(0.00226)
Observations	2,821	2,821
R-squared	0.442	0.394
Fixed effects	I C-Y	I C-Y

Note: Estimates obtained from the model in Equation 7. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 11 countries (Belgium, Canada, Chile, Croatia, Finland, France, Hungary, Italy, Latvia, the Netherlands, and Sweden). Observations are weighted by the industry level aggregate of value added, normalised at the country level. I and C-Y indicate fixed effects for the industry and country-year, respectively. Standard errors given in parentheses are clustered at the country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

Productivity growth in connected industries may not only affect employment in a given industry, but also the wages that workers are earning in it. Column 1 of Table 5.7 shows that both upstream and downstream productivity growth in domestic industries appear to have positive value chain spillovers on the average wage in a given industry. For the corresponding terms related to foreign productivity growth, the point estimates are also positive and indicate a similar pattern, but estimation uncertainty does not allow to draw any definitive conclusion. Furthermore, consistent with previous results (columns 2 and 3 of Table 5.5,

Figure 5.2.), the first row of this result shows that wage growth of a given industry depends strongly on own-industry productivity growth. Taken together, these results imply a strong and positive role of productivity growth for economy-level wage growth.

This result is also emphasised by column 2 of Table 5.7, which shows the link of productivity growth to the wage bill, i.e., the product of total employment and the average wage in the industry. The total wage bill is strongly and positively related to own-industry productivity growth through the previously discussed link of productivity with average wages. The total wage bill is also further related to supplier productivity growth which matters strongly for employment growth, as discussed above. Productivity growth in customer industries also tends to increase the total wage bill, but to a lower extent than productivity growth arising from supplier industries.

Putting together the conclusions of this section, productivity growth does not appear to have a direct negative impact on employment changes at more aggregate levels. Instead, if anything, when considering both within-industry and between-industry patterns, productivity changes appear on average positively related to employment growth at the more aggregate level. This suggests that productivity changes may not only benefit firms that experience those, but they have also positive implications for more aggregate outcomes. The results also highlight that productivity growth benefits workers through higher wages within the same industry, and further through value chain spillovers. Productivity growth has the potential to increase own-industry employment if markets are sufficiently contestable – in which case the amount of job creation associated with the productivity-induced reallocation process may more than offset the negative impacts on shrinking and exiting firms– and if demand is sufficiently elastic, i.e. if industry output can expand strongly in response to productivity growth.

Table 5.7. Wage spillovers of industry-level productivity growth along the value chain

	(1)	(2)
	Change in average wage	Change in total wage bill
Change in own-industry productivity	0.0560***	0.0841***
	(0.0170)	(0.0280)
Change in domestic supplier productivity	0.00539*	0.0106**
	(0.00322)	(0.00474)
Change in domestic customer productivity	0.00301*	0.00379
	(0.00165)	(0.00280)
Change in foreign supplier productivity	0.00264	0.0158**
	(0.00364)	(0.00639)
Change in foreign customer productivity	0.00328	0.00347
	(0.00208)	(0.00344)
Observations	2,819	2,819
R-squared	0.967	0.912
Fixed effects	I C-Y	I C-Y

Note: Estimates obtained from the model in Equation 7. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 11 countries (Belgium, Canada, Chile, Croatia, Finland, France, Hungary, Italy, Latvia, the Netherlands, and Sweden). Observations are weighted by the industry level aggregate of value added, normalised at the country level. I and C-Y indicate fixed effects for the industry and country-year, respectively. Standard errors given in parentheses are clustered at the country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

6 Discussion and policy implications

Analysing the link between productivity growth and changes in employment and wages is key to better understand the extent to which technological progresses and organisational changes are linked to labour market outcomes. This is central for the inclusiveness of economic growth.

The data collected in the context of the OECD MultiProd project have allowed carrying out a uniquely comprehensive investigation of this relation. Indeed, for the first time this study relies on highly representative official data from 13 countries to focus on different levels of aggregation with unprecedented detail.

The main insights of the analysis are briefly summarised in Figure 6.1 and further discussed below, considering their implications for economic policy.

On average, productivity growth is positively associated with employment growth. This net positive relation holds at different levels of aggregation and suggests that boosting productivity is also key for employment. Increasing productivity is also associated with higher wages, further highlighting that productivity-enhancing policies are likely to bring double dividends for other relevant outcomes.

The overall net positive link between productivity growth and changes in employment is the result of counteracting mechanisms. At the firm level, the net relationship results from direct labour-saving effects – related to efficiency and possibly further to automation and other labour-replacing technologies – and indirect employment-generating effects – related to higher demand and expansion in market shares.

The positive link between productivity growth and changes in employment found in the analysis suggests that on average the latter (positive indirect effect) tends to outweigh the former (direct negative effect). Results are consistent with the idea that firms improving their position relative to competitors are able to attract higher demand, with positive and persistent returns in terms of employment. Even when negative effects are likely to be stronger, such as in industries that use more intensively ICTs, the link between productivity and employment growth remains positive, although milder. Productivity growth also increases the chances of firm survival, with positive implications for labour demand.

The firm-level role of productivity for employment depends on a firm’s position in the within-industry productivity distribution, that is, its initial productivity performance relative to other firms in the same industry.

While leading firms at the frontier of the productivity distribution experience on average higher employment growth, less productive firms that catch up towards the frontier relevantly experience stronger employment growth than other firms, after accounting for initial differences in productivity. Fostering innovation, on the one hand, and boosting its diffusion across the whole economy, on the other hand, seem therefore key policy objectives that may play a crucial role not only to sustain productivity, but also to increase employment growth.

Figure 6.1. Overview of main findings

	Micro Level Within-firm Dynamics	Industry and Aggregate Level Within-industry mechanisms Between-industry mechanisms
Productivity-Employment Link	Positive	Positive
Key drivers	• Productivity performance *relative* to competitors ("catch-up to the top") • Top productivity performers generate employment growth irrespective of productivity change	• Shift in market shares in favour of productivity-improving firms • Supplier industries inducing employment changes downstream (along domestic and global value chains)
Key mechanisms	• Indirect (+) mechanism related to increased sales and market share overcompensates a… • Direct (-) mechanism reated to efficiency and possibly capital-labour substitution (ICTs, AI)	• Productivity-induced job reallocation • Better intermediates and input complementarities boost downstream employment

Complementary insights	• Productivity growth is positively related to
	  • Firm survival
	  • Wage growth
		• Productivity growth induces wage growth
		  • Within the originating industry
		  • Along the value chain

Note: authors' elaboration based on the results of the analysis.

A positive relation at the firm level may not necessarily mean that productivity growth translates into employment growth to the same extent at more aggregate levels. Indeed, increasing employment in some firms may come at the expense of a reduction in employment for other firms, such as those losing their competitiveness or exiting the market, making the within-industry employment outcomes more ambiguous. Furthermore, industries do not operate in isolation, but are interlinked into value chains. Productivity changes in one industry are therefore likely to spill over into employment changes also in other industries. The analysis sheds novel light in this respect, thanks to the unique granularity of the OECD MultiProd data, in combination with other databases collected by the OECD.

Results show that also at a more aggregate level productivity growth is associated with positive changes in labour demand, reflected both in increasing employment and in higher wages. In addition, increasing employment among expanding firms tends to outweigh decreasing employment in shrinking or exiting ones. These patterns likely reflect changes in market shares across firms.

Less contestable markets, which may be reflected by asymmetries in market power, appear to be a factor that may slow down these dynamics, likely limiting the extent to which some firms – especially those with a high potential for growth – may gain market shares and expand in terms of employment when they improve their productivity. Fostering competition and ensuring the contestability of markets is therefore key in this context.

In addition, productivity gains at the industry level contribute to stronger employment growth in other industries through value chains. In particular, productivity growth in upstream industries is positively associated with employment growth in downstream industries, further corroborating the idea that productivity gains are on average labour enhancing not only at the firm level but also at the more aggregate one.

Overall, this evidence suggests that boosting productivity is not only a standalone economic objective, but also an important one for labour demand. Indeed, productivity growth is on average accompanied with employment and wage growth across different levels of aggregation. As such, labour demand and productivity represent complementary rather than alternative policy targets.

Well-designed complementary policies have therefore the potential to boost both productivity and employment. To achieve both objectives, a multi-pronged policy approach may aim at enhancing productivity, and promoting the conditions that help translate technological and organisational change into higher employment and wages, also taking into account the fact that gains and losses may contribute differently to welfare and inclusiveness. Policies may thus be articulated around three complementary goals: i) enhancing productivity; ii) providing the conditions for productivity growth to translate into employment and wage growth; iii) ensuring inclusiveness of productivity growth and the associated change in labour demand.

Several policy areas can help achieve these goals. Policy should be oriented at fostering: innovation and its diffusion; skills; competition; reallocation while paying attention to inclusiveness; integration in value chains; aggregate demand. These are detailed further below.

On the one hand, policy makers can enhance productivity growth by supporting technology diffusion, boosting the capabilities of laggard firms and increasing their potential to catch up, which turns out to have significant positive implications also for job creation and wages.

In this context, policy should boost human capital, strengthening the quality of education systems and allowing the workforce to cope with the changes in skills demand related to technological change. STEM education and training appear particularly relevant in this context. Policy should not only aim at boosting the skills of workers, but also the capabilities of managers, since they play a key role not only in technology adoption decisions, but also in the extent to which new technologies and organisational practices materialise into productivity gains.

To further promote diffusion, policies should aim at alleviating relevant financial barriers, which may be particularly challenging in the intangible economy. Enabling access to ICT and digital infrastructure, supporting research and development, especially for young and small innovative firms, and fostering technology transfer and university-industry collaborations may further help increase absorptive capacity and foster technology diffusion.

On the other hand, policy makers should foster innovation, considering the important role it may have for labour demand by raising productivity growth. Policy should therefore continue fostering the production and sharing of knowledge. Key policy levers in this area are related to encouraging research – including basic one – and development, supporting the creation of innovation network and innovation ecosystems, and providing incentives or support for R&D.

Ensuring a level playing field and the contestability of markets is equally key in this context. This is not only crucial for productivity but also to allow productivity gains related to innovation and diffusion to generate employment growth. This analysis has shown that asymmetries in market power, signalling the presence of top firms whose strong position on the market cannot be easily challenged, may be associated with less positive employment effects of productivity-improving technological and organisational changes.

Reducing barriers to entry for new firms, which may drive the introduction of radical innovations, and levelling the playing field, which may also foster post-entry growth, appear particularly important. This is even more relevant considering the recent declines in business dynamism and increases in industry concentration documented by recent OECD analysis. In addition, understanding how competition authorities can develop better tools to limit firms' market power and its adverse consequences on business sector innovation and growth seems also of utmost importance.

The economic environment should relevantly allow leveraging spillovers arising from value chains. Indeed, the analysis highlights that productivity growth in domestic and foreign supplier industries may strengthen employment growth in downstream industries. Integration to global and domestic value chains and connections to increasingly productive supplier industries may be therefore particularly beneficial for the economy, and restoring value chain links when these have been disrupted appears therefore relevant. In addition, targeting productivity growth and innovation in upstream industries may contribute to aggregate employment growth indirectly through positive effects on downstream industries.

The strengthening of value chains and internationalisation of firms may also further contribute to foster aggregate demand. This seems particularly important given the role of scale and market size in ensuring returns in terms of employment growth from productivity improvements.

Given that both productivity growth and the related job creation and wage increases occur through creative destruction, it is key to maintain an environment in which reallocation of resources occurs, while paying attention to inclusiveness. Indeed, there is ample evidence that this reallocation process may not benefit all equally, favouring some occupations over others, due to the disappearance of tasks replaced by capital and the emergence of new ones that complement technologies. This in turn advocates for policies supporting both the transition of displaced workers to new occupations, but also for training to allow workers to upskill, enabling those that lose their jobs at shrinking or exiting firms to be then matched with high productivity firms, and supporting this transition.

Summing up, a comprehensive policy mix that leverages synergies across policy areas appears key, in particular one aimed at fostering innovation and technology diffusion, competition and reallocation, while supporting the transition of displaced workers and improving their skills. Such policies would not only be beneficial for productivity but are likely to have double dividends also for employment and wages, fostering an inclusive economic growth.

7 Conclusions and next steps

This report investigates how productivity growth relates to the dynamics of employment and wages at different levels of aggregation and over different countries, industries, and time horizons. The micro-aggregated data collected in the context of the OECD MultiProd project, which collects highly representative official data from 13 countries for the period 2000-2018, enables a uniquely comprehensive investigation of the relation between productivity growth and the dynamics of employment and wages.

These data allow to study the productivity-employment nexus by focusing on different levels of aggregation, looking at i) the link between firm-level productivity growth and firm-level employment (and wage) growth, as well as the link with firm survival: ii) the link between industry-level productivity and employment growth in the same industry and iii) the link between productivity growth in some industries and employment growth in other industries through value chain connections.

Overall, results point to a positive link between productivity growth and both employment and wages growth. This net positive relation holds at different levels of aggregation and suggests that boosting productivity is also key for employment. However, the strength of the link varies according to the level of aggregation considered.

Focusing on within-firm growth, results show a net positive and significant productivity-employment nexus, which is the outcome of mechanisms that act in opposite directions. At the firm level, an indirect labour-creating effect – related to higher demand and expansion in sales – seems to prevail on a direct labour-saving effect – related to efficiency and possibly further to automation and other labour-replacing technologies. Moreover, the extent to which firms' productivity and its growth translate into positive employment changes, although positive on average, is not the same for all firms. While leading firms at the frontier of the productivity distribution experience on average higher employment growth, after accounting for initial productivity, less productive firms that catch up towards the frontier relevantly experience stronger employment growth than other firms.

When looking at the link between productivity growth and changes in employment and wages at the industry level, the report finds again a positive correlation, although weaker than at the firm-level. Beyond the direct and indirect mechanisms described before, the industry-level link is relevantly shaped by a reallocation process, which implies that job creation among expanding firms tends to compensate decreasing employment in shrinking or exiting ones. Furthermore, less-contestable markets as signalled by highly asymmetric market power across firms appear to be a factor that may slow down the positive link between productivity growth and changes in employment, as they represent an impediment to the aforementioned reallocation process. Finally, productivity growth in upstream industries is positively associated with employment growth in downstream industries, corroborating the idea that productivity gains are on average labour-enhancing not only at the firm level but also at the more aggregate one.

Overall, this evidence suggests that boosting productivity is not only a standalone economic objective, but may also contribute to welfare through its role for employment and wages. The fact that productivity growth is on average accompanied with employment and wage growth across different levels of aggregation implies that labour demand and productivity represent complementary rather than alternative policy targets.

Well-designed complementary policies enhancing productivity can help translate technological and organisational change into higher employment and wages. A multi-pronged policy approach aimed at targeting at the same time potential adopters of new technologies – i.e., diffusing technology, knowledge and innovation – and their providers – i.e., focusing on the supply of technology, knowledge and innovation – might therefore increase both productivity growth and improve labour market outcomes. Moreover, given that both productivity growth and the related job creation and wage increases occur through creative destruction, it is key to maintain an environment in which reallocation of resources occurs, while paying attention to inclusiveness. Finally, results of this report suggest that policies should also be aimed at fostering a competitive environment and spillovers from value chains.

The analysis conducted in this report has leveraged the MultiProd database to provide an analysis of the productivity-employment nexus that shed lights on the relevant mechanisms at play from a complementary micro- and macro-economic perspective. This study, that provides an encompassing view of the relationship, could be extended in several ways, to focus more in detail on specific mechanisms.

First, as the report showed that both at the firm level and at the industry level an indirect employment-generating effect prevails over a direct labour-saving one, it would be interesting to further explore more directly the relative importance of some of the mechanisms at play. Just to mention a few: variation in prices, variation in sales, increase in different types of efficiency (technology, managerial efficiency, etc.). Future analysis could also further investigate the dynamic firm-level relationship between technological change, productivity growth and employment, for instance focusing more in detail on the pass-through between the adoption of new technologies and intangible assets, productivity growth and firm-level developments in terms of sales and employment growth, over different time horizons. These analyses are challenging to conduct from an international perspective, but additional insights may arise from the matching of micro-economic databases available in single countries.

Second, future work may further investigate some of the firm-level relationships using directly firm-level data, complementing the insights from the current cross-country analysis based on micro-aggregated data (e.g., estimating additional distributed country-specific regression models). This may allow to further explore changes in the relationships over time (for instance declines in the responsiveness of employment to productivity over time, or changes over the business cycle), asymmetries that may arise between negative and positive productivity shocks, as well as the role of the life cycle of firms.

Third, this report has highlighted the importance of reallocation and market contestability for the productivity-employment nexus. On the one hand, defining markets is challenging and additional work may refine the analysis providing complementary insights, also shedding further light on specific sectoral dynamics. On the other hand, further empirical analysis of the role of policies in other areas – within or across countries – focusing not only on their impact on employment and productivity separately, but on their role for both outcomes, may provide additional policy-relevant insights. In particular, future work may further investigate the role of regulations and institutions (for instance employment protection legislation, unionisation, etc.) for the productivity-employment nexus.

Fourth, the role of structural change may be explored more directly, focusing on how long-term shifts in sectoral compositions may affect the productivity-employment nexus in the long run. This would require longer time series than the ones used in this work, which may be available in the future.

Finally, future work may further explore the extent to which productivity changes are associated with changes among specific groups of workers, using complementary sources at the industry level, or measuring more directly their skills, or focusing further on workers at disadvantage in labour markets, using linked employer-employee data.

Endnotes

[1] Acemoglu and Restrepo (2018[1]) indeed show that over the period 1980-2015, new tasks and new job titles have accounted for a large fraction of US employment growth.

[2] Relatedly, but focusing on labour shares rather than overall employment, Autor et al. (2020[63]) link the decline in labour share to an increase in the market share of productivity leaders, who use capital more intensely and have higher profits (Koch, Manuylov and Smolka, 2021[25]).

[3] Acemoglu, Lelarge and Restrepo (2020[23]) however find that expansion of firms adopting automation technologies comes at the expense of their competitors, inducing an overall negative impact of robot adoption on industry employment.

[4] Jaimovitch and Siu (2020[64]) notice that the job losses related to routine-replacing technological change occur during recessions and contribute to job polarisation and to jobless recoveries.

[5] Specifically, initial technological change may occur in an environment of elastic demand allowing firms to significantly increase output, and therefore labour demand, in response to increased productivity. Eventually, the opportunity to scale output with productivity may decrease due to saturation of demand, causing further technological progress to have a lower, potentially negative, effect on employment.

[6] The BR is not needed when administrative data on the full population of firms are available. When data come from a PS, however, the availability of the business register substantially improves the representativeness of results and, thus, their comparability across countries.

[7] Additional details on MultiProd can be found in Berlingieri, Blanchenay and Criscuolo (2017[69]) and on the MultiProd webpage https://www.oecd.org/sti/ind/multiprod.htm. See also Desnoyers-James, Calligaris and Calvino (2019[73]) for more information on metadata.

[8] SNA-A38 is an industry classification based on 2-digits ISIC revision 4 classification, with some 2-digit industries aggregated together. The correspondence between ISIC rev. 4 and SNA A38 is available in Berlingieri et al. (2017[45]). The ISIC revision 4 industries 19 (Manufacture of coke and refined petroleum products) and 68 (Real estate activities) are excluded from the analysis.

[9] The analysis uses mostly the information on the transitions over a five-year horizon or ten-year horizon.

[10] The relevant variables to investigate firm-level outcomes correspond to a weighted average of firm-level log-changes, with weights corresponding to inverse probability weights computed from the MultiProd re-weighting procedure. More formally, for each cell C in the data, the variables x_C are computed as follows:

$x_C^h = \frac{1}{W_C} \sum_{i \in C} w_i [ln(X_{i,t}) - ln(X_{i,t-h})]$,

where w_i are the inverse probability weights of firm *i,* derived from the re-weighting procedure (see Berlingieri et al. (2017[45])). $W_j = \sum_{i \in C} w_i$ is the sum of weights in cell *C* (i.e., a country, industry, year and transition group).

[11] DynEmp is another distributed micro-aggregated data project led by the OECD Directorate for Science Technology and Innovation focusing on business and employment dynamics. More information is available at the DynEmp webpage: https://www.oecd.org/sti/dynemp.htm.

[12] The productivity distribution is divided into five parts: the very bottom, the bottom, the median group, firms above the median but not at the frontier, and frontier firms. These groups are defined according to percentiles of the productivity distribution, and correspond respectively to the 1st to 10th, 10th to 40th, 40th to 60th, 60th to 90th, and 90th to 100th percentiles.

[13] The choice of the timing is guided by the aim of analysing the dynamic relationship of productivity growth and changes in employment. Such analysis is able to avoid issues related to the relevant quantities being simultaneously determined. Choosing *t+5* as the horizon of employment change is further guided by data availability. Of the horizons available from the transition matrix data (3, 5, 7, 10, and 14), this horizon balances the interest in a sufficiently long-term view of the impact of productivity on employment on the one hand and the availability of sufficiently many cohorts and observations on the other one. Unreported results confirm that the observed key relationships hold also when considering the link of productivity growth between *t* and *t+5* to employment growth from *t* to *t+10*, and also from the contemporaneous link of productivity growth between t and *t+5* to employment growth from *t* to *t+5*.

[14] Additional unreported regressions also augment Equation 3 including leads of productivity, in order to account for the role of future productivity growth, and provide qualitatively similar results.

[15] The median group, used as the reference group, is composed of firms between the 40th and 60th percentiles of the productivity distribution. Note that this set of results accounts for differences in initial size ("initial employment") across groups of firms with different initial productivity.

[16] At the same time, results also show that future employment growth of firms initially at the very bottom of the productivity distribution ("Initial productivity group p0-p10") is relatively higher than that of firms in the reference group and in the productivity group below the median ("Initial productivity group p10-p40"). This result may be driven by positive selection of firms in this group, as it is populated by a selected group of laggard firms that survive over the next five years. These firms are more likely to be start-ups with a high potential for growth and catch-up (Berlingieri et al., 2020[54]).

[17] Decker et al. (2020[7]) find that the responsiveness of employment growth to productivity has declined over time in the United States. At present, it is not possible to fully investigate the dynamic patterns of the relationship with the data at hand, as the cohorts of firms on which the analysis is based are only available in certain years (see presentation of data in the dedicated section). Preliminary evidence suggests that the association between productivity growth and employment growth may have to some extent declined over time, but further analysis is required to infer robust conclusions on this. To this end, future analysis directly exploiting firm-level data through distributed regressions may allow to investigate these patterns more in detail and may provide relevant complementary insights.

18 This result is based on the estimation of the model using the micro-aggregated data for firms surviving over the horizon considered (five years). This is necessary to study the dynamic adjustment of employment over the horizon considered, but the estimates do not account directly for the productivity-employment link among firms that exit in the shorter term. It is not possible to directly investigate how this selection affects the estimates with the data at hand. However, results are robust and similar when considering the relationship at different time horizons (i.e., employment growth after 3, 5, 7 or 10 years, conditional on data availability) for which the strength of firm selection may vary. In addition, unreported results show that the relationship between employment dynamics from time *t* to *t+3* and initial productivity growth is positive and significant also for firms that exit between time *t+3* and *t+5*. Thus, these results suggest that the positive relationship between employment growth and initial produticitivity growth is not driven by the selection of firms that survive over the horizon considered.

19 The panel of countries for which data are available may be relatively heterogenous with respect to economic institutions, maturity or levels of productivity, but the correlation between firm-level productivity growth and employment growth appears robust to its composition. Indeed, results are qualitatively similar when focusing on different sub-groups of countries. For instance, unreported results are very similar when focusing on all EU countries in the sample, or on G7 countries in the sample. Results are also confirmed when focusing on countries that joined the European Union in 2004 or before (EU15), though the correlation between initial within-firm productivity growth and employment growth appears to some extent smaller for this group.

20 The fixed effects structure implies that the estimation mainly relies on the variation of employment and productivity growth across firms within a country-industry-year. A highly similar coefficient estimate is also obtained when using an even less restrictive set of fixed effects absorbing only specificities of countries, years, and industries separately, and also when not accounting for the initial productivity group. Results are also robust when including average age as a control. Average age is not included in the main model due to lack of data availability for some countries. Results are also confirmed by unreported regressions focusing on the link between contemporaneous employment growth and productivity growth over the same five-years period (i.e., productivity and employment growth from *t* to *t+5*), as well as regressions focusing on five-year employment growth (*t+5* to *t+10*) after an initial five-year period of employment and productivity growth from *t* to *t+5* (based on transitions of firms across productivity groups over a ten-year horizon). This confirms that results hold when focusing on longer-term changes in productivity which may reflect additional structural changes compared to short-term productivity shocks. Additional unreported results based on the estimation of the model omitting initial employment growth, in which the contemporaneous association between initial productivity growth and employment growth is also captured by the relevant coefficient, also highlight a positive correlation between productivity growth and employment growth.

21 Table A A.1 in the appendix further confirms the importance of relative productivity growth for the total firm-level relationship of productivity growth to employment growth. The results show that when accounting for a firm's productivity group at the end of the transition, the remaining relationship between productivity growth and changes in employment strongly reduces. Therefore, this result underscores that while productivity growth is positively linked to employment growth to the extent that it helps firms improve their position in the productivity distribution, it is otherwise less strongly associated with employment growth.

22 Comparing panels (a) and (b) of the figure, which rely on two different sets of fixed effects, confirms that also in the impulse response setting, allowing for broader variation of productivity (and employment) growth to dynamics that are not only relative to competitors in the same country-industry-year (as done by the model with country-industry and country-year fixed effects in panel (a)) does not significantly alter the

estimated response. This confirms that changes in the position in the productivity distribution (i.e., the change in the ranking in terms of productivity performance) matters more than absolute changes in productivity for employment dynamics.

[23] In Table 4.3 the first row shows the link between productivity growth and employment growth for the reference group comprised of the bottom of the productivity distribution (firms below the 40th percentile of the productivity distribution). The second row shows the difference in the relation for firms which are not at the bottom neither at the frontier with respect to the reference group. The third row shows the difference between the baseline coefficient and the coefficient for the frontier group. The coefficient for the frontier group is 0.066 (0.148-0.082) which indicates that employment growth is still positively correlated with productivity growth for frontier firms.

[24] It is noteworthy that the link between productivity growth and future employment growth holds for firms in all productivity groups. In particular, results in Table 4.3 suggest that the strength of the association between employment growth and productivity growth is similar for non-frontier firms in the middle upper part of the productivity distribution (p40-p90) and for firms at the bottom of the productivity distribution (p0-p40), which are also more likely to be young firms for which productivity may be underestimated as they charge lower prices. This suggests that results hold overall across firms, and are not driven only by start-ups with initially lower productivity. Future work may further investigate the role of firms' life cycle regarding the strength of the relationship, including the role of young firms growing to optimal size.

[25] ICT intensity (based on the work of Calvino et al. (2018[44])) is measured as investment in ICT equipment as a percentage of total gross fixed capital formation. The measure used in this report is a cross-country average over the period 2000-2003. It varies at the industry level only, which helps to address limitations related to data availability. Note that while ICTs were key in the computerisation of routine tasks over the period after 1980 and form the basis of modern automation technologies related to robotics, machine learning and AI, some ICTs also complement labour, e.g., software related to navigation, design, planning and organisation, surveillance and monitoring, etc., so that the concept is not immediately to be equated with labour-saving technological change.

[26] The variables on patents are constructed from information from the OECD Patstat database. These data measure the annual number of patents filed related to either technology (ICT, AI) at the country level. The patent count is normalised by the total number of employees in the country-year from the OECD STAN database to measure patenting intensity relative to the size of the economy. Specifically, AI patents are divided by millions, and ICT patents by thousands of employees.

[27] The estimated coefficients imply that the link between firm-level productivity growth and firm-level employment growth remains positive also in sectors with high ICT intensity. This is also in line with results by Aghion et al. (2020[24]), showing that the firms adopting automation technologies may be able to benefit from productivity growth and increase their market shares.

[28] The difference between the 90th and 50th percentile of the markup distribution provides a measure of markup dispersion more specifically at the top. This choice is driven by the aim to have a conservative measure: existing literature shows that differences in markups across firms are driven by the top half of the markups distribution (Calligaris, Criscuolo and Marcolin, 2018[52]; De Loecker, Eeckhout and Unger, 2020[67]), with the bottom part having markups very close to 1. This implies that while "few firms have high markups and are large, the majority firms see no increase in markups and lose market share" (De Loecker, Eeckhout and Unger, 2020[67]). Therefore, the measure considered seems to be a more conservative choice when looking at dispersion than, for instance, the difference between 90th and the 10th percentile.

[29] Low contestability of markets may in particular affect firms with initially lower productivity (which tend to be smaller and younger, with less market power) by reducing their benefits associated with catching up to the frontier. However, according to the results in this report, these firms are precisely those with the highest potential for employment growth in response to productivity growth, and any barriers they face in expanding their market may therefore significantly impact the average relationship between productivity growth and changes in employment.

[30] The results on market power dispersion are also relevant for the role of market power itself. Unreported results confirm that the patterns observed are similar when considering the 90^{th} percentile of the within-industry distribution of markups, rather than markup dispersion. Hence, the positive link between firm-level productivity growth to employment growth may be more generally limited by the presence of high markup firms, whose stronger position might not be easily challenged. Further, high markup firms themselves might be less prone to increase their production inputs when productivity increases, as they may rather retain the benefits of lower marginal costs and higher margins.

[31] The link between initial firm-level productivity growth and future employment growth may also change according to other dimensions that may capture additional differences across sectors regarding e.g. technical efficiency, R&D intensity, industry maturity, use of intangible assets and skills. Preliminary evidence using either an industry-level proxy of industry maturity (age of global frontier firms), or the industry share of top firms in terms of sales, or intangible intensity, does not show compelling evidence so far. Future research may further explore the role of industry characteristics possibly also exploiting other complementatry measures, if data allow.

[32] Unreported results displaying the quantile fixed effects in the regression reported in Table 4.6 confirm that the probability of exit is also negatively associated with the initial level of productivity. The lower the initial productivity relative to others, the higher the risk of exit.

[33] Results are also confirmed when focusing on various sub-groups of countries (for instance restricting the panel to EU countries, or countries that joined the EU in 2004 or before). Additional unreported preliminary results also investigate possible heterogeneity across countries related to employment protection legislation, focusing on differences that may arise between countries that differer according to the strength of regulations on dismissals and the use of temporary contracts. Preliminary results do not show statistically significant differences so far. Future research could further investigate the role of institutions and policies in shaping the relationship, focusing on particular mechanisms at the firm or industry level.

[34] The measure of multifactor productivity used in this report uses value added as the output variable and two inputs, capital and labour. A value added based measure has the advantege to overcome the lack of information on intermediates, which is not always available and/or accurate. However, it does not take into account complementarities of intermediates with capital and labour. For the micro level, information on firm-level dynamics according to a productivity measure based on a sales production function that includes intermediates as an input is currently not included in the MultiProd database, but it could be in the future. However, at the higher level of aggregation for which the measures are available, unreported results confirm the main findings using such a productivity measure.

[35] DynEmp is a distributed micro-aggregated data project led by the OECD Science Technology and Innovation directorate focusing on business and employment dynamics. More information is available at the DynEmp webpage: https://www.oecd.org/sti/dynemp.htm .

36 The job reallocation rate corresponds to the sum of job creation and destruction rates. Excess job reallocation rates measures the extent of job reallocation on top of what is required to accommodate net employment growth.

37 As in the previous section, the continuous markup dispersion variable measures the difference between high and median markups within a country-industry pair each year, where high markups are proxied by the 90th percentile of the within country-industry-year distribution of markups. See the previous section for further details.

38 More specifically, the instrument is constructed as the product of five-year productivity growth at the global frontier for each industry (computed from the ORBIS dataset) and the change in annually filed AI patents (computed from the PATSAT dataset) normalised by millions of employees (computed from the STAN dataset), in each country.

39 This finding is consistent with the direct negative own-industry effect found by Autor and Salomons (2018[2]).

40 An industry *k* is considered upstream relative to an industry *j* if *k* supplies intermediate inputs to *j*. Industry *k* is the (upstream) supplier industry and industry *j* is the customer (downstream) industry.

41 Unreported results suggest that omitting the role of foreign suppliers leads to an overestimation of the spillovers arising from domestic suppliers.

42 The magnitude of the estimated relationship appears to be quantitatively relevant. Grouping countries into two equally-sized groups according to the productivity growth performance of their domestic suppliers, an unreported initial quantification (based on the estimates of Table 5.6, column 1, row 2) suggests that employment growth appears higher in the group with stronger average supplier productivity growth and that differences in domestic supplier growth may account for a relevant proportion (around one-third) of the overall differences in employment growth between the two groups.

43 Additional unreported results investigate the role of upstreamness at the industry level, using a measure of forward centrality – which measures the share of an industry in all downstream connections of the production network – to proxy for the upstream importance of an industry (Criscuolo and Timmis, 2018[72]). This preliminary evidence suggests that also the own-industry link of productivity growth to employment growth may be more positive in these industries.

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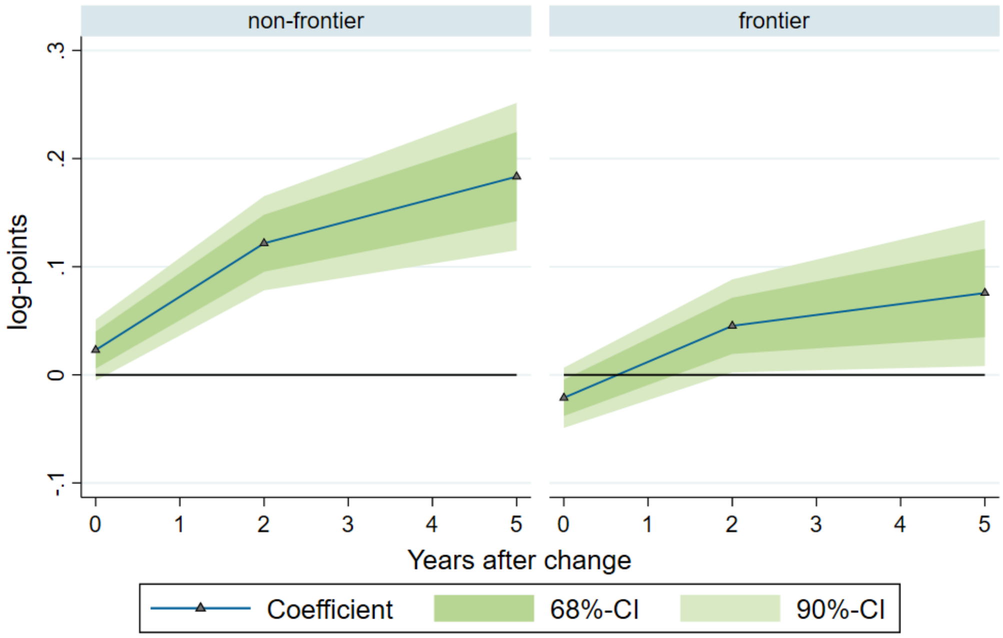
Annex A. Additional tables and figures

Table A A.1. The firm-level link between productivity catch-up and employment growth vs. other aspects of productivity growth: partial correlation model

	(1)	(2)	(3)
	5-year change in employment	5-year change in employment	5-year change in employment
1-year change in productivity	0.134***		0.0345
	(0.0334)		(0.0234)
Final productivity group p10-p40		0.141***	0.110***
		(0.00819)	(0.00729)
Final productivity group p40-p60		0.202***	0.158***
		(0.0131)	(0.0127)
Final productivity group p60-p90		0.216***	0.171***
		(0.0198)	(0.0192)
Final productivity group p90-p100		0.144***	0.115***
		(0.0306)	(0.0278)
1-year change in employment	1.824***		1.610***
	(0.0842)		(0.0770)
Initial employment	0.00951	-0.0486***	-0.0158**
	(0.00653)	(0.00922)	(0.00753)
Observations	19,900	19,875	19,356
R-squared	0.398	0.554	0.670
Fixed effects	C-I-Y G	C-I-Y G	C-I-Y G

Note: Estimates obtained from an extension of the model in Equation 1. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 9 countries (Belgium, Croatia, Hungary, Italy, Japan, Latvia, the Netherlands, Portugal and Sweden). Observations are weighted by the number of firms represented in the full population, normalised at the country level. C-I-Y indicates fixed effects for the country-industry-year, and G indicate fixed effects for the initial productivity group. Standard errors given in parentheses are clustered at country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

Figure A A.1. The role of a firm's initial position for the firm-level link between productivity growth and employment growth: dynamic model



Note: This figure illustrates the results of the local projection impulse response regression estimations for the response of employment to a change in productivity, based on a heterogeneous effects extension of the model in Equation 3 that further interacts the impulse variable with an indicator that is equal to one if the cell represents firms initially above the 90th percentile of the within-industry productivity distribution ("frontier") and equal to zero otherwise ("non-frontier"). The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 9 countries (Belgium, Croatia, Hungary, Italy, Japan, Latvia, the Netherlands, Portugal and Sweden). Observations are weighted by the number of firms represented in the full population, normalised at the country level. Confidence bands are based on pointwise estimation of standard errors, clustered at the country-industry level.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

Table A A.2. The role of the firm's initial position for the firm-level relationship between productivity growth and the risk of exit

	(1)
	Exit
5-year change in productivity	-0.0923***
	(0.0192)
* Initial productivity group = p10-p40	-0.211***
	(0.0250)
* Initial productivity group = p40-p60	-0.219***
	(0.0311)
* Initial productivity group = p60-p90	-0.120***
	(0.0440)
* Initial productivity group = p90-p100	0.0221
	(0.0338)
Initial Employment	-0.0977***
	(0.0230)
Observations	13,486
Fixed effects	C-I-Y G

Note: Estimates report average partial effects and are obtained from a heterogeneous effects extension of the logistic regression model Equation 4. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 7 countries (Belgium, Italy, Japan, Latvia, the Netherlands, Portugal and Sweden). Observations are weighted by the number of firms represented in the full population, normalised at the country level. C-I-Y indicates fixed effects for the country-industry-year, and G indicates fixed effects for the initial productivity group. Standard errors given in parentheses are clustered at country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database

Table A A.3. The role of structural determinants for the industry-level link between productivity growth and employment growth: contemporaneous relationship

	(1)	(2)	(3)
	5-year change in employment	5-year change in employment	5-year change in employment
5-year change in productivity	0.0110	0.0102	-0.00198
	(0.0188)	(0.0221)	(0.0202)
* ICT investment intensity	-0.0112**		-0.0107**
	(0.00432)		(0.00531)
* Difference p90-p50 of markups		-0.0147	-0.00863
		(0.00983)	(0.00920)
Initial employment	-0.0958***	-0.104***	-0.103***
	(0.0200)	(0.0234)	(0.0232)
Initial aggregate productivity	0.00750	6.72e-05	0.00247
	(0.00722)	(0.00794)	(0.00793)
Difference p90-p50 of markups		0.000753	0.000272
		(0.00262)	(0.00287)
Observations	2,713	1,966	1,966
R-squared	0.548	0.564	0.570
Fixed effects	I C-Y	I C-Y	I C-Y
Countries excluded	-	CAN, CHL, FRA	CAN, CHL, FRA

Note: Estimates obtained from a modification of the model in Equation 2. The regressions are based on a sample including 22 SNA A38 industries within manufacturing and non-financial market services across 12 countries (Belgium, Canada, Chile, Croatia, Finland, France, Hungary, Italy, Japan, Latvia, the Netherlands, and Sweden). Observations are weighted by the industry level aggregate of value added, normalised at the country level. I and C-Y indicate fixed effects for the industry and country-year, respectively. Standard errors given in parentheses are clustered at country-industry level, and statistical significance is denoted as follows: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations based on the OECD MultiProd 2.0 Database