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The Great Divergence(s)

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Abstract

This report provides new evidence on the increasing dispersion in wages and productivity using novel micro-aggregated firm-level data from 16 countries. First, the report documents an increase in wage and productivity dispersions, for both manufacturing and market services (excluding the financial sector). Second, it shows that these trends are driven by differences within rather than across sectors, and that the increase in dispersion is mainly driven by the bottom of the distribution, while divergence at the top occurs only in the service sector, and only after 2005. Third, it suggests that between-firm wage dispersion is linked to increasing differences between high and low productivity firms. Fourth, it suggests that both globalisation and digitalisation imply higher wage divergence, but strengthen the link between productivity and wage dispersion. Finally, it offers preliminary analysis of the impact of minimum wage, employment protection legislation, trade union density, and coordination in wage setting on wage dispersion and its link to productivity dispersion.

Keywords: dispersion, productivity, sorting, wages
JEL codes:D2; J3

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EXECUTIVE SUMMARY

The last decades have been characterised by rising wage inequality, which can be largely attributed to an increase in wage dispersion between- rather than within-firms. At the same time, recent evidence indicates that there has been a significant increase in productivity dispersion, suggesting that there might be a positive relationship between the two divergences in wages and productivity.

This report contributes to this body of research by providing new evidence on the increasing dispersion in wages and productivity using novel micro-aggregated firm-level data for 16 countries. The dataset contains information about productivity dispersion and wage dispersion, based on the full population of firms in each country or made representative for the population using re-weighting. We can summarise the findings of the report in five main takeaways:

1. Between-firm wage dispersion is found to be significantly and positively correlated to the overall wage dispersion across workers and its evolution over time. Most of the between-firm wage variance is driven by differences in pay across firms within sectors rather than by differences in average wages across sectors. There has been a steady increase in wage inequality, measured as the 90-10 wage ratio, driven mainly by an increased dispersion in the lower tail (50-10 ratio); the divergence of the upper tail (90-50 ratio) only happens in the service sector and only since 2005.
2. Similarly, we find that dispersion in productivity, whether measured as real value added per worker (labour productivity) or as multi-factor productivity (MFP), has also significantly increased in the last decade. Most of the increase is driven by within-sector productivity differentials across firms, rather than by cross-sectoral differences. Similar dynamics of increase at the bottom throughout the entire period and at the top only after 2005 are also present in the productivity data, which might point to a link between the co-evolution of wage and productivity dispersions.
3. Wage dispersion is linked to increasing differences between high and low productivity firms, even controlling for the sectors' skill composition. Firm-level correlation between wages and productivity is systematically weaker at the top and at the bottom of the productivity distribution.
4. Both globalisation, as indicated by measures of greater openness, greater import penetration and greater export intensity at the sectoral level, and digitalisation, measured by more intense use of ICT capital at the sectoral level, are associated with higher wage divergence, and tend to strengthen the link between productivity and wage dispersion within sectors and countries over time.
5. Finally, the report provides some preliminary analysis of the impact of policies and institutions on the link between wage inequality and productivity dispersion focusing on minimum wage, employment protection legislation, trade union density, and coordination in wage setting. The results point to a positive link between higher minimum wages, unionisation, EPL, coordination in wage setting, and reduced wage inequality, but usually accompanied by a weaker link between productivity and wages, especially for more centralised wage bargaining. On the contrary, over time, the minimum wage tends to strengthen the link between productivity and wage dispersion.

"Why are similar workers paid differently? Why do some jobs pay more than others? I have argued that wage dispersion of this kind reflects differences in employer productivity... Of course, the assertion that wage dispersion is the consequence of productivity dispersion begs another question. What is the explanation for productivity dispersion?"

— Mortensen (2003, p. 129)

1. INTRODUCTION

Over the last three decades several OECD and non-OECD economies have experienced increasing inequality in income between the rich and the poor (OECD, 2016; Piketty, 2014) and in earnings between workers, for instance between high- and low-skilled workers (Autor et al., 2003), and between those employed in large versus small businesses (Song et al., 2015). At the same time divergence is becoming evident also amongst businesses: between high and low productivity firms (OECD, 2015; Andrews et al., 2016); between those with high and low returns to capital (Furman and Orszag, 2015); and between large and small firms (Mueller et al., 2015).

Recent evidence suggests that these trends might be intertwined. A significant part of the rising income inequality observed in the last decades in OECD economies can indeed be accounted for by rising earnings inequality, which in turn is driven by an increase in the wage differentials between firms. In fact, the important role of the increase in between-firm wage differentials as the most significant driver of the increase in earnings inequality has been found in different countries: in Brazil (Helpman et al., 2017), Denmark (Bagger et al., 2013), Germany (Baumgarten, 2013; Card et al., 2013; Goldschmidt and Schmieder, 2015), Italy (Card et al., 2014), Portugal (Card et al., 2016b), Sweden (e.g. Håkanson et al., 2015), the UK (Faggio et al., 2010), and in the US (Dunne et al., 2004; Barth et al., 2014; Song et al., 2015).[1]

This widespread evidence hints to the fact that the forces driving the increase in between-firm wage dispersion are likely to be global rather than just specific to a single country. Some of the evidence goes one step further in identifying productivity as an important element of the "between-firm" component (Davis and Haltiwanger, 1992; Mortensen, 2003; Dunne et al., 2004; Faggio et al., 2010; Christensen and Bagger, 2014). However, the debate is still open, in particular regarding the main factors driving this trend and the role that policies and institutional factors have in determining them. Most analyses of the increase in wage inequality have focused on the role of information and communication technologies (ICT) and the increase in globalisation and trade competition, especially from low-wage countries.

As suggested by Mortensen (2003, see quote above), if the increase in "between-firm" differences plays such an important role in accounting for the overall increase in wage inequality, then a natural question arises: what drives the productivity dispersion? And, more importantly, what are the possible causes of its evolution over the last decades? Recent studies point to an increase in within-sector productivity

[1] See also Card et al. (2016a) for a recent overview.

dispersion globally (Andrews et al., 2016) and within countries, e.g. Italy (Gatto et al., 2008; Calligaris et al., 2016), Japan (Ito and Lechevalier, 2009), the UK (Faggio et al., 2010), and the US (Decker et al., 2017). As to wages, the jury is still out on what is the main driver driving this divergence: in particular, the questions remain on the relative contribution of globalisation and digitalisation to these trends and how much policies have mediated their impact on wage inequality.[2]

It is therefore important to understand not only the link between the observed divergences in wages and productivity, but also how structural changes, such as globalization and digitalization, affect this link. The evidence here is much more scarce and in this report we take some initial steps towards exploring these links. Moreover, from the perspective of policy makers, it is essential to gather evidence on whether policies and institutional features affect wage inequality and their evolution vis-à-vis structural changes, and whether they do so without weakening the link between the distribution of wages and productivity.

This report contributes to this research literature by providing new evidence on the 'divergences' in productivity and wages using a novel data source, collected in the OECD MultiProd project, based on the full population of firms, or a representative re-weighted sample, for 16 countries (Section 2). The analysis sheds light on the nature of the increase in wage inequality, with a particular focus on the link with productivity dispersion and its determinants - structural changes such as globalisation and digitalisation. The report also provides new evidence on the link with policies and institutions and the role these might have in attenuating the impact of structural change. In the report, we focus on the role of pay-setting institutions (minimum wage levels, employment protection legislation, wage setting, and unions) and outline the next steps for looking at the role of product market regulation (PMR), such as barriers to entry and barriers to trade and investment.

We try to contribute to the debate in several ways. First, we provide new evidence on the evolution of between-firm wage dispersion across 16 countries from the mid-1990s to the recent post-recession period 2012 (Section 3). We start by showing that, even though we only have information on average wages at the firm level, the picture of inequality we provide is still relevant: the inequality measures based on our between-firms measures are indeed strongly correlated with measures based on earnings at the individual level. Moreover the newly collected data from the MultiProd project allow us to look at different measures of dispersion using firm-level data. The evidence suggests that an important divergence occurred in wages offered by firms, even within the same sector.

Second, the report looks at the evolution of productivity dispersion using representative data for the full population of firms (Section 4). The MultiProd data allow us to use different measures of productivity (both labour and multi-factor productivity) and its dispersion, and to quantify the importance of within- versus between-sector dispersion in explaining the overall trends.

Third, we document the evolution of the wage-productivity link over the same period and, thanks to the richness of the data, we investigate the extent to which wages and productivity are correlated along

[2] E.g. wage setting policies and institutions such as minimum wage, trade unions, wage coordination, employment protection legislation and product market regulation.

the whole productivity distribution, as well as control for other features, such as the firm age and skill composition at the sectoral level (Section 5).

Fourth, we conduct a new analysis of the role of technological changes, increased globalisation, and changes in the competitive environment and the institutional framework in explaining changes in productivity dispersion, wage inequality, and the relationship between the two (Section 6). The current analysis aims at identifying economic and statistically significant relations and does not aim at identifying causality. Robust and economic significant conditional correlations and interactions between the policy environment and changes in the technology and global environment are still informative.

Last, but not least, we conduct a new analysis of the role of pay-setting institutions and features of the labour market that might attenuate the impact of structural changes on wage dispersion and on the link between productivity and wage dispersion (Section 6.2).

In previous research, three potential explanations of the increase in productivity dispersion have been brought to the table. First, the important role of technological change: different rates of adoption of new technologies might lead to increased productivity dispersion and, in turn, to increased wage inequality (see in particular Caselli, 1999). This result might emerge through the persistent co-existence of a dual economy with, on the one hand, high-paying high-productivity firms employing the new technology and high-skilled workers, and, on the other hand, low-paying low-productivity firms employing the old technology (Acemoglu, 1998). Second, growing globalisation and the increased integration of economies will affect the distribution of productivity (Melitz, 2003). The mechanisms at play might have countervailing effects on productivity dispersion. Trade might lower dispersion as a consequence of the exit of the least productive firms due to the increase in competition. At the same time, trade might increase dispersion because of differences across firms in how much they can benefit from knowledge spillovers and from the increased demand provided by the larger (global) market size. On top of this, recent evidence suggests that an increase in trade, in the form of increased import competition from low wage countries such as the People's Republic of China (hereafter "China"), might push some firms to innovate and adopt IT technologies (Bloom et al., 2016), which again might increase dispersion. Third, changes in the competitive environment and firm organization, such as increases in consolidation or changes in demand (Syverson, 2004), might also lead to higher dispersion.

Technological progress and globalisation have also been put forward as sources of change in the distribution of wages, and the increase in wage inequality in particular. For instance the increase in import penetration and offshoring has put workers in direct competition with low-skilled low-paid workers in developing countries (e.g. China starting in the late 1990s), bringing down their wages and increasing wage inequality (Autor et al., 2013). Similarly, skill-biased technological change, through the rise of ICT, increases the productivity and the demand of high-skilled workers, thus raising their relative wages vis-à-vis low-skilled workers (Card and DiNardo, 2002; Autor and Acemoglu, 2011). In addition to globalisation and skill-biased technological change, research has focused on the role of policy and institutions in explaining the observed increase in wage dispersion, in particular the decline in real minimum wage (DiNardo et al., 1996) and for the UK and the US in unionisation (e.g. Card et al., 2004, and for an overview Machin, 2016). For continental European economies the focus has been on the centralization level of bargaining, given that, even in countries with low union densities, bargaining agreements are generality extended to non-unionised workers (see Card and Rica, 2006, Dell'Aringa and Pagani, 2007, and more recently Dahl et al., 2013). The evidence linking the centralisation of wage bargaining and wage dispersion is mixed and often based on cross-sectional analysis. Recent studies based on longitudinal matched employer-employee data (e.g. Dahl et al., 2013, using Danish data) suggest that decentralization of wage bargaining is associated with higher wage dispersion. They also find evidence that under firm level bargaining wages are more likely to reflect individual productivity, thus their result might also suggest a stronger alignment between firm-level wages and productivity distributions.

Much less evidence exists on the role of policies and institutional factors in mediating the effects of globalization and technological change on wage inequality. In recent years evidence from France (Carluccio et al., 2015), from Germany (Baumgarten, 2013) and Sweden (Håkanson et al., 2015) suggest that collective wage agreements might dampen the effect of trade on wage inequality.

More recently, a growing body of evidence points to the fact that much of the increase in wage inequality of individuals can be attributed to a rise in the variance of wages between establishments rather than within them, as found by Dunne et al. (2004) and more recently by Barth et al. (2014), who show that the growth in the between-establishment wage dispersion contributed to around 79% of the growth in the variance of individual wages between the 1970s and the 2010s in the United States. Even more sharply, Song et al. (2015) conclude that the increased dispersion of average earnings across firms accounted for a large part of the steep increase in US individual earnings inequality during 1982-2012. A similar important role for between-firm dispersion has been found in other countries: Brazil (Helpman et al., 2017), Germany (Card et al., 2013; Goldschmidt and Schmieder, 2015), Italy (Card et al., 2014), and Sweden (Skans et al., 2009; Håkanson et al., 2015).

This strand of research points to the important role played by sorting (of workers) and assortative matching as potential reasons for the growing role of employers' heterogeneity in accounting for the rise in wage inequality.[3] The mechanism is explained by the fact that the most productive workers increasingly work for the most productive firms, with a clustering of high-skilled workers in high-paying firms. Rent sharing, i.e. workers of high profit - high productivity firms enjoying a share of the firms' rents, is also found to play a role in explaining this trend (Card et al., 2014; Card et al., 2013).

This growing 'segregation' of high-productivity workers in high-productivity, high-paying firms might reflect the increase in the use of domestic outsourcing by firms: non-core activities are outsourced to other firms, cutting low-skilled workers in low-skilled occupations from the rent sharing (Goldschmidt and Schmieder, 2015). But the segregation might also reflect the increasing importance of skill-skill or skill-capital complementaries, the role of trade (Helpman et al., 2017), and technological change (Dunne et al., 2004; Håkanson et al., 2015) in line with the theoretical models of Caselli (1999) and Acemoglu (1998). Finally if there is rent sharing, the widening gap between workers in high- versus low-paying firms might reflect the widening in profits and profitability across firms, which in turn might lead to

[3]For recent evidence of the increase in sorting over the last two decades see, for example, Bagger et al. (2013)

lower worker mobility and entrepreneurial ventures, i.e. to lower dynamism in the economy (Furman and Orszag, 2015).

The rest of the paper is organised as follows: in section Section 2, we describe the new data source and the measures that we use for the analysis. Sections 3 and 4 provide evidence on the evolution of, respectively, between-firm wage dispersion and productivity dispersion across 16 countries from the mid-1990s to the recent post-recession period 2012. Section 5 investigates the evolution of the wage-productivity link. Section 6 analyses the role of structural factors and policies on wage divergence and its link to increased productivity dispersion.

2. DATA

This sections provides an overview of the data, and the main measures of productivity and of dispersion used in the report. More details on the data sources, the variables available in MultiProd and the methodology are available in Berlingieri et al. (2017).

2.1 Data source: the OECD MultiProd project

The analysis conducted in this report relies on the work undertaken in the last few years within the OECD "MultiProd" project. The data collected in MultiProd are computed by running a standardised STATA® routine on firm-level data based on production surveys and business registers, via a *distributed microdata analysis*. This is a method of collecting statistical moments of the distribution of firm characteristics (employment, productivity, wages, age, etc.) by a centrally written routine that is flexible and automated enough to run across different data sources in different countries.

In recent years, the policy and research communities' interest in harmonised cross-country microdata has increased significantly, mainly reflecting the recognition of the need of microdata for understanding the growing complexity in the way economies work. Significant obstacles remain, however, for transnational access to official microlevel data. The rationale for undertaking a distributed microdata analysis is to create harmonised cross-country statistics and, at the same time, overcome the confidentiality constraints of firm-level datasets by providing detailed protocols and programs to accredited researchers in each country. It was pioneered in the early 2000s in a series of cross-country projects on firm demographics and productivity (Bartelsman et al., 2005; Bartelsman et al., 2009). The OECD currently follows the distributed microdata approach in three ongoing projects: MultiProd, DynEmp and MicroBerd.[4]

The MultiProd program relies on two main data sources in each country. First, administrative data or production surveys (PS), which contain all the variables needed for the analysis of productivity but may be limited to a sample of firms. Second, a business register (BR), which contains a more limited

[4] The DynEmp (Dynamics of Employment) project provides harmonised micro-aggregated data to analyse employment dynamics (Criscuolo et al., 2014; Criscuolo et al., 2015) and MicroBerd provides information on R&D activity in firms from official business R&D surveys.

set of variables (mainly employment, sector of activity, age and ownership) but for the entire population of firms. The program works also in the absence of a business register and this is not needed when administrative data on the full population of firms are available. However, when data come from a PS, its availability substantially improves the representativeness of the results and, thus, their comparability across countries. In particular, given the coverage and the continuity of the administrative information collected for each firm, BR data allow for: i) the calculation of the population breakdowns necessary for obtaining the sampling weights used in the analysis; ii) a much more precise treatment of entry and exit; iii) the calculation of more precise sectoral modes and conversion tables in case of changes in the sectoral classification at the firm level - as the whole life cycle of the business is observed - or of a change in the whole sectoral classification system - as the entire population of businesses is observed.

At the time of writing, 16 countries have been successfully included in the MultiProd database (namely, Australia, Austria, Belgium, Canada, Chile, Denmark, Finland, France, Hungary, Italy, Japan, Luxembourg, Netherlands, Norway, New Zealand and Sweden). For most countries the time period spans from early 2000s to 2012. For Luxembourg, Belgium and Chile the time horizon is shorter (starting in 2003, 2004 and 2005 respectively), whereas for Finland, France, Japan and Norway data are available at least since 1995.

Table 1: Data coverage

Country	Years	Firms	Employees
Australia	2002-2012	68,499	761,602
Austria	2008-2012	255,701	2,258,626
Belgium	2003-2011	102,574	1,804,465
Canada	2000-2012	509,460	8,058,557
Chile	2005-2012	339,492	5,273,453
Denmark	2000-2012	80,030	1,281,035
Finland	1995-2012	85,038	981,772
France	1995-2012	812,850	11,453,356
Hungary	1998-2012	191,064	1,786,685
Italy	2001-2012	312,057	1,893,156
Japan	1994-2011	25,786	10,552,236
Luxemburg	2003-2012	1,136	105,252
Netherlands	2000-2012	39,375	332,449
Norway	1995-2012	63,593	890,001
New Zealand	2000-2011	90,973	992,208
Sweden	2002-2012	176,652	1,889,764

Note: Manufacturing and services only. Numbers are averages across years.

Table 1 details years covered, and for each of these years, the average number of firms and employees by country. The high number of firms and employees represented in our data allows us to get an accurate picture of the overall wage inequality, as we show in Section 3.1. Still, one of the big challenges of conducting cross-country analysis of firm-level data when only production surveys are available is that comparing selected samples of firms might yield a partial and biased picture of the economy. Whenever available, business registers, which typically contain the whole population of firms, are therefore used to compute a population structure by year-sector-size class. This structure is then used to re-weight the data contained in the production surveys in order to construct micro-aggregated data that are as representative as possible of the whole population of firms and hence comparable across countries.

Table 2: Representativeness, 2010

	Share of firms (%)		Share of employment (%)	
	BR	BD	BR	BD
Austria		69		92
Belgium		70		97
Denmark		100		115
Finland	98	100	98	100
France		100		107
Hungary		92		99
Italy	11	11	52	52
Netherlands	7	5	57	44
Norway		71		89
Sweden		96		87

Note: Share of firms present in MultiProd compared to Business Register data (BR) and to the Eurostat annual Business Demography by size class database (BD). Manufacturing and non-financial market services only. Year 2010.

Table 2 shows for 2010 the share of firms and employment with respect to both the BR (when available) and statistics on the population of firms from the Eurostat annual Business Demography by size class database (BD), which is based on the Eurostat-OECD Manual on Business Demography Statistics.[5] Comparing across different data sources is never easy, but data from the BD database give a good benchmark to compare our data. The table is constructed for the manufacturing and non-financial market service sectors, and the BD data refer to the total number of firms in a country or the total number of firms with at least one employee in accordance with the micro-data used in MultiProd. The coverage is rather high in most of the countries, and for those with a lower coverage the full BR is available, and thus the samples can be re-weighted. For instance Italy has a skewed distribution with a large mass of very small firms which cannot be captured by production surveys. The survey used by MultiProd contains only 11% of the total population of firms (both with respect to the BR and to the BD data) but it accounts for 52% of total employment. At the same time we have access to the entire population of firms from the business register, which we use to reweight our sample moments. In the Netherlands the situation is similar, with the only existing survey of firms representing a very small share of firms, but the BR allows us to re-weight those firms in order to make the reported statistics representative of the total economy.[6]

[5] Similar figures were calculated for other years but are not reported for brevity. They are available from the authors upon request.

[6] In the Netherlands the coverage of the survey changes year by year as Statistics Netherlands surveys a larger number of firms in some benchmark years; for instance, in 2009 the share of firms covered by the survey increases to 8.7% with respect to the BR and 6.9% with respect to BD data.

2.2 Measures of productivity

The analysis relies on three measures of productivity. The first, labour productivity, is the most widely used in the literature and aims at capturing the amount of output produced by a firm for a given amount of labour input. It is computed at the firm level as the (real) value-added per worker:

$$\text{LP\_VA}_{it} = \frac{VA_{it}}{L_{it}} \tag{1}$$

where VA_{it} is the value-added of firm i at time t, and L_{it} is its employment.[7] The advantage of this measure is that it is widely available, and fairly immune to measurement error. Moreover, it can be easily aggregated into sector-level or country-level labour productivity using employment weights.

One of the main drawbacks of labour productivity is that it does not quantify the impact of other inputs, such as capital, while for some policy questions it might be important to disentangle whether labour productivity gains are actually driven by an increase in physical capital. In order to do this, the MultiProd data contain two measures of multi-factor productivity (henceforth MFP), which is a productivity measure that accounts not only for labour but also for capital productivity.[8]

The main measure of MFP in the data, that we label MFP_W, is estimated econometrically at the firm-level using Wooldridge (2009) instrumental variable approach and value added as a measure of output. Firms are assumed to have a Cobb-Douglas production function, but not necessarily constant returns to scale:

$$Y_{it} = A_{it} K_{it}^{\beta_K} L_{it}^{\beta_L} \tag{2}$$

where A_{it}, firm i's MFP at time t, is typically unobserved and has to be estimated. Rewriting Equation (2) in logs:

$$y_{it} = \beta_K k_{it} + \beta_L l_{it} + (\omega_{it} + \varepsilon_{it}) \tag{3}$$

where we split the unobserved $\log A_{it}$ into ω_{it}, the component known to the firm, and ε_{it}, the component that is not. Since ω_{it} is known to the firm at the time of choosing its inputs k_{it} and l_{it}, these will be correlated with ω_{it} and therefore with $\log A_{it}$. A straightforward OLS estimation of Equation (3) would yield the following productivity estimate:

$$\widehat{\log A}_{it} = y_{it} - \widehat{\beta_L^{OLS}} l_{it} - \widehat{\beta_K^{OLS}} k_{it} \tag{4}$$

This estimate is likely to be biased because k_{it} and l_{it} are correlated with the error term in Equation (3).

Instrumental approaches to solve this problem were pioneered by Olley and Pakes (1996), who suggested using investment as a proxy for productivity. Due to its volatility and lumpiness (leading to the

[7] For the sake of maximising cross-country comparability we rely on headcount (HC) for measuring labour input since it is the one most commonly available in the countries considered; only when HC is not available, we rely on full time equivalents (FTE).

[8] For the MFP calculations a measure of capital stock is needed. If information on investment is available, the capital input is measured through the Perpetual Inventory Method (PIM); otherwise, the deflated book value of capital is used.

presence of many zeros), investment presents several limitations;[9] to remedy this, Levinsohn and Petrin (2003) suggested a two-step estimation procedure that uses intermediate inputs as a proxy. However, Ackerberg et al. (2006) pointed out that identification of the coefficient on the variable input (e.g. labour) is likely problematic in Levinsohn and Petrin (2003), for instance due to the presence of hiring and firing costs or other frictions.[10] This identification problem can be overcome with the one-step procedure suggested by Wooldridge (2009), which, while more data-intensive, allows for the identification of the variable input and yields consistent standard errors without the need for bootstrapping. The procedure relies on estimating variable inputs with a polynomial of lagged inputs and a polynomial of intermediates. This is the approach on which our main measure of MFP, which we label MFP_W, relies.

For robustness, we also include a non-parametric measure of MFP that does not rely on production function estimation. More specifically, we compute a productivity measure similar to a Solow residual, which we label MFP_SW, by assuming the following production function in gross output:

$$Y_{it} = A_{it} M_{it}^{\beta_M^{SW}} L_{it}^{\beta_L^{SW}} K_{it}^{\beta_K^{SW}} \tag{5}$$

where input elasticities β_M^{SW}, β_L^{SW} and β_K^{SW} of firm i are assumed to be the sector-specific median of factor shares across countries and years. With an additional assumption of constant returns to scale, productivity is computed in logs:

$$\text{MFP\_SW}_{it} = \log GO_{it} - \beta_L^{SW} l_{it} - \beta_M^{SW} m_{it} - \left(1 - \beta_L^{SW} - \beta_M^{SW}\right) k_{it} \tag{6}$$

While this measure is less data intensive, it relies on important assumptions, departures from which would bias this measure of productivity. Nonetheless, most results obtained when using our estimated MFP_W also carry through using MFP_SW.

2.3 Measures of dispersion

In order to capture heterogeneity in the data, we calculate several measures of productivity and wage dispersion within macro-sectors and 2-digit industries.[11] This report focuses on four measures of dispersion: variance; and 90-10, 90-50, 50-10 ratios. MultiProd also calculates other measures such as the interquartile range, i.e., the difference between the 75$^{\text{th}}$ and the 25$^{\text{th}}$ percentile, and the standard deviation. Another measure of dispersion used in literature is the ratio between mean and median, which can also be easily calculated.[12]

In this report we will focus on the measures of dispersion shortly described below:

[9] Due to the presence of capital adjustment costs, the investment function may be non-monotonic in ω_{it} and non-invertible.

[10] See Ackerberg et al. (2015) for the published version.

[11] More precisely the data of MultiProd are collected at the A38 level, which is slightly more aggregated than 2-digit (for the exact definition, see Berlingieri et al., 2017). Still, we use the two terms interchangeably throughout the paper. Outcomes are also available at a more aggregated A7 or macro-sector level.

[12] This ratio can help to quickly assess the skewness of a distribution: the distribution is right-skewed if the ratio is greater than 1 while is left-skewed if the ratio is less than 1, and the further from 1 is the value the more skewed is the distribution.

- The variance is defined as the expectation of the squared deviation of a random variable from its mean, and as such it measures how far a set of observations are spread out from their mean. In the literature it is probably the most used measure to assess how stretched or squeezed the distributions of wages and productivity are. In the report we decompose the variance of wage and productivity in: (i) a within and between sector component; (ii) in a within and between-quantile of the productivity distribution (for wages only).
- 90-10 wage (productivity) ratio is defined as the ratio between the 90th and the 10th percentile of the wage (productivity) distribution. It is used widely in both the inequality and the productivity literature to assess the spread of the distribution of wages and productivity. The measures are quite intuitive since a ratio of X can be interpreted as 'firms at the top of the wage (productivity) distribution, proxied by firms at the 90th percentile, paying (or producing, given the same amount of inputs) X times as much as firms at the bottom of the distribution, proxied by firms at the 10th percentile'.
- 90-50 wage (productivity) ratio is defined as the ratio of the 90th percentile to the 50th percentile, i.e. the median, of the wage (productivity) distribution. It captures dispersion in the upper tail of the distribution.
- 50-10 wage (productivity) ratio is defined as the ratio of the 50th percentile to the 10th percentile of the wage (productivity) distribution. It captures dispersion in the bottom tail of the distribution.

3. DIVERGENCE IN WAGES

3.1 Overall vs between-firm inequality

The database of the MultiProd project is constructed using data sources at the level of the firm. This implies that the measure of wages contained in the dataset, firm's total labor costs divided by the number of employees, corresponds to the average wage at the firm level and that the dispersion of wages within the firm is not observed. Therefore whenever we discuss wage dispersion we analyse the dispersion of wages between firms, and not the overall dispersion of workers' wages. This is because at present the MultiProd network does not have access to matched employer-employee data sources that would be needed to carry out the analysis both at the worker and at the firm level. This means that we cannot control for worker level characteristics (such as age, experience, tenure, gender and education), nor calculate overall or within-firm wage dispersion.[13]

When analysing the evolution of overall wage inequality in the last decades, this is a clear shortcoming, but not as severe as it might appear. There is in fact mounting evidence that the observed increase in overall wage inequality over time is driven by increasing between-firm wage differentials, as

[13] An analysis with matched employer-employee data has not been attempted because of the higher level of complexity that this would entail in terms of coordination both within and across countries, but most importantly because such an analysis would severely limit cross-country comparison as these data are not yet available in many countries. A future step of the MultiProd project will be to access matched employer-employee data for a subset of countries in which the data are available.

opposed to within-firm differences due to worker specific characteristics. For instance amongst OECD economies, evidence for the US (Dunne et al., 2004; Song et al., 2015) shows that over two thirds of the increased wage inequality observed in the last three decades is accounted for by increased variance across businesses. In Germany, the increase in wage variance across workers and across businesses seem to contribute equally to the increase in overall wage inequality (Card et al., 2013), with evidence for Sweden (Håkanson et al., 2015) and Italy (Card et al., 2014) following a similar pattern.[14] Similar evidence has also been found for emerging economies: Helpman et al. (2017) find that in Brazil the between-firm component accounts for 86% of the increase in wage inequality within sectors and occupations over the 1986-1995 period, while worker observables only account for 2% of the total and the residual within-firm component is even negative.

The widespread evidence that a significant part of the increase in earnings inequality observed in the last decades is driven by an increase in the wage differentials between firms prompts us to conclude that, despite the data limitations mentioned above, we can draw meaningful conclusions for trends in overall wage inequality.[15]

To demonstrate that this limitation is not too severe, we start by showing that the observed between-firm measure of wage inequality drawn from the MultiProd data is meaningfully related to the overall wage inequality. Lacking matched employer-employee data to carry out a formal decomposition of the overall wage inequality in the between- and within- components, we relate our measure of between-firm wage inequality to the aggregate wage inequality in earnings available from the OECD Earnings Distribution Database (EDD). This analysis is limited by the fact that data on overall inequality in earnings are available only at the country level and often over a more limited period than in the MultiProd database. Hence sectoral level regressions cannot be carried out.

Table 3 reports the estimates of a pooled OLS regression, where the dependent variable is the overall earnings dispersion measured as the 90^{th}-10^{th} percentile ratio and the regressors are the between-firm wage dispersion, also measured as the 90^{th}-10^{th} percentile ratio, calculated within macro-sectors, countries and years. The country and sectoral coverage is limited by data availability in the EDD and in MultiProd.[16] For all macro-sectors considered, the overall earnings inequality at the country level is strongly significant and positively correlated with the MultiProd between-firm wage dispersion.

[14] Note that thanks to the availability and accessibility of matched employer-employee several studies have focused on Germany (e.g. Card et al., 2013; Goldschmidt and Schmieder, 2015; Baumgarten et al., 2016) and Sweden (e.g. Skans et al., 2009; Akerman et al., 2013; Håkanson et al., 2015)

[15] A caveat of the within-sector between-firm analysis carried out in the rest of the report is that the occupation structure is not observed in the micro-data. This contrasts with studies where the object of interest is the residual wage inequality between workers with the same characteristics (e.g. sector, occupation, education etc.) employed in different firms. To overcome this issue we will control for the level of skills at the sectoral level over time, which can partially capture the changing occupation structure at the sectoral level. We intend to extend the current analysis in future research to explicitly control for the occupation and skill structure at the sectoral level. In any case it is reassuring that Helpman et al. (2017) find that the sectoral component is more important than the occupation component (it accounts for a larger share of the overall change in wage inequality: 27% versus 8% of the occupation component).

[16] The largest set of countries include: Australia, Austria, Belgium, Canada, Chile, Denmark, Finland, France, Hungary, Italy, Japan, Luxembourg, Netherlands, Norway, New Zealand and Sweden.

Table 3: Overall country-level wage inequality on sectoral between-firm inequality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Agriculture, Forestry and Fishing [A]	0.051^{***}						
	(0.014)						
Mining and quarrying [B]		0.045^{***}					
		(0.005)					
Manufacturing [C]			0.055^{***}				
			(0.008)				
Electricity, gas, water, and waste [D-E]				0.055^{***}			
				(0.011)			
Construction [F]					0.065^{***}		
					(0.010)		
Non-Financial Market Services [G-N]						0.045^{***}	
						(0.007)	
Non Market Services [O-U]							0.050^{***}
							(0.008)
N	118	152	163	154	145	163	162
Adj. R-Square	0.097	0.281	0.189	0.194	0.173	0.184	0.214
Num. Countries	11	14	16	15	15	16	15

Robust standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
The dependent variable is the inequality in earnings (90-10 percentile ratio) from the OECD Earnings Distribution database.
The regressor is the between-firm wage inequality (90-10 percentile ratio) in the relevant sector.

Table 4: Overall country-level wage inequality on sectoral between-firm inequality (within-country variation)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Agriculture, Forestry and Fishing [A]	0.016						
	(0.013)						
Mining and quarrying [B]		0.003					
		(0.016)					
Manufacturing [C]			0.038				
			(0.063)				
Electricity, gas, water, and waste [D-E]				-0.009^{*}			
				(0.005)			
Construction [F]					0.065^{***}		
					(0.015)		
Non-Financial Market Services [G-N]						0.057^{***}	
						(0.011)	
Non Market Services [O-U]							0.014^{***}
							(0.004)
N	51	69	69	69	51	69	69
Adj. R-Square	0.932	0.944	0.944	0.945	0.946	0.959	0.948
Country FE	3	4	4	4	3	4	4

Robust standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
The dependent variable is the inequality in earnings (90-10 percentile ratio) from the OECD Earnings Distribution database.
The regressor is the between-firm wage inequality (90-10 percentile ratio) in the relevant sector.

Further, we investigate whether changes in wage inequality at the country level are related to changes in between-firm wage dispersion at the sectoral level. Given the limited amount of country-level longitudinal information on overall earnings dispersion, we can only conduct the panel data analysis on four countries (Finland, France, Japan and Norway). Nonetheless, we find that the evolution of overall earnings dispersion in these countries is related to the changes in between-firm wage dispersion from the MultiProd database (Table 4). The correlation is significant and positive for construction, non-financial market services and non-market services, which is not surprising given that the dependent variable is at the country level and that these are the largest sectors, accounting for more than two thirds of overall employment.[17]

Overall, these results reassure us that, even if we can analyse only the between-firm wage dispersion, our results can still provide valuable evidence related to overall wage inequality.

3.2 Divergence in between-firm wage dispersion

Now that we have shown that between-firm wage dispersion and its changes over time capture a significant part of the overall wage dispersion both in the cross-section and over time, we examine the evolution of between-firm wage dispersion and provide evidence for why it makes sense to speak of a "Great Divergence".

3.2.1 The evolution of between-firm wage dispersion

To analyse the increase in wage dispersion more accurately we focus on its evolution within countries and disaggregated sectors, to make sure that wage dispersion at the macro-sector level is not driven by a compositional effect of more disaggregated sectors. More precisely, we use an econometric approach that removes country by 2-digit sector fixed effects, as shown in the following regression:

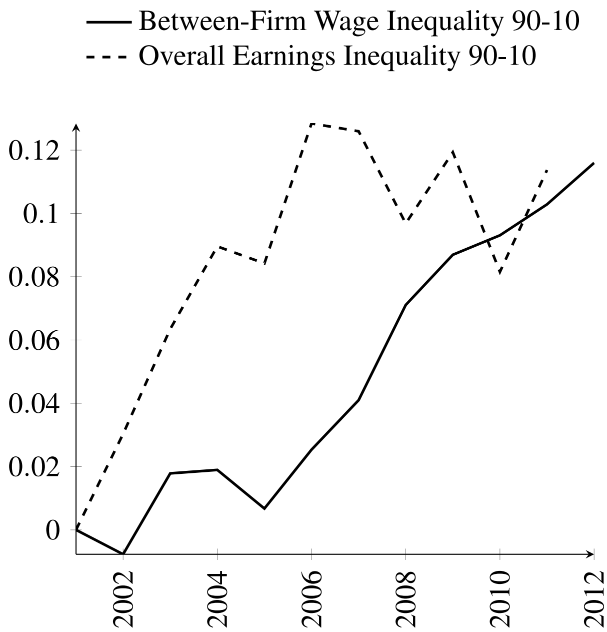
$$(\log W_{90} - \log W_{10})_{cjt} = \alpha + \beta_t y_t + z_{cj} + \varepsilon_{cjt} \tag{7}$$

where W_{90} and W_{10} are respectively the 90$^{\text{th}}$ and 10$^{\text{th}}$ wage percentiles, and where c denotes countries, j 2-digit sectors and t years.[18] Year dummy estimates β_t capture the average dispersion in a given year controlling for specific country-sector fixed effects z_{cj}. The latter control for the specific levels of dispersion in each country and sector, so that the estimates of the year dummies coefficients β_t capture a more accurate evolution of wage dispersion within each 2-digit sector in each country.

[17] In results not reported here we find that the correlation more than doubles in magnitude and becomes significant also in agriculture and mining when the 90$^{\text{th}}$-50$^{\text{th}}$ percentile ratio is analysed.

[18] Since the data in MultiProd are micro-aggregated moments (and means in particular) from firm-level data, in all regressions we weight each observation cjt by the number of firms reporting a non-missing information for the relevant variable in a given country-sector-year (using analytical weights in STATA®).

Figure 1: The "Great Divergence" of wages
Wage dispersion over time within sectors and countries



Note: The solid line plots the estimated year dummies β_t of a regression of log-wage dispersion (90th and 10th percentiles difference) within country-sector pairs, as estimated in Equation (7) using data from the following countries: AUS, AUT, BEL, CHL, DNK, FIN, FRA, HUN, ITA, JPN, NLD, NOR, NZL, SWE . As a reference, the dashed line plots the year dummy estimates of a similar regression using the overall inequality in earnings from the OECD Earnings Distribution database within each country. The data on overall inequality are only available at the country level and for a more limited set of countries: FIN, FRA, HUN, JPN, NOR, NZL for the whole period; AUS, ITA, SWE from 2002; and NLD between 2002 and 2010.

Figure 1 shows that within-country sector wage dispersion has been increasing over time, indicating that by 2012, the within country-sector 90-10 wage ratio is 12.3% higher than in 2001.[19] It is in that respect that it makes sense to speak of a "Great Divergence" of wages. To get a sense of the magnitude of the results and whether the between-firm wage dispersion captures a meaningful share of overall wage inequality, we run a similar regression using the overall wage inequality in earnings from the OECD Earnings Distribution database. Figure 1 shows that the evolution of overall wage inequality follows a similar pattern, and in particular that the magnitude of the increase over the analysed period is a remarkably similar (12.1 % in 2011). It is not possible to draw strong conclusions from this comparison because of differences in the data sources and availability (data on overall inequality are only available at the country level and for a more limited set of countries). But the results clearly show that the increase in the between-firm wage dispersion is in the same ballpark figure as the increase in overall earnings inequality.[20]

Our main result concerning the Great Divergence of wages should not hide the fact that there exists important variation across countries in our sample. Figure 2 plots log changes in the 90-10 wage ratio from 2001, within each country and separately for manufacturing and services. For instance in both

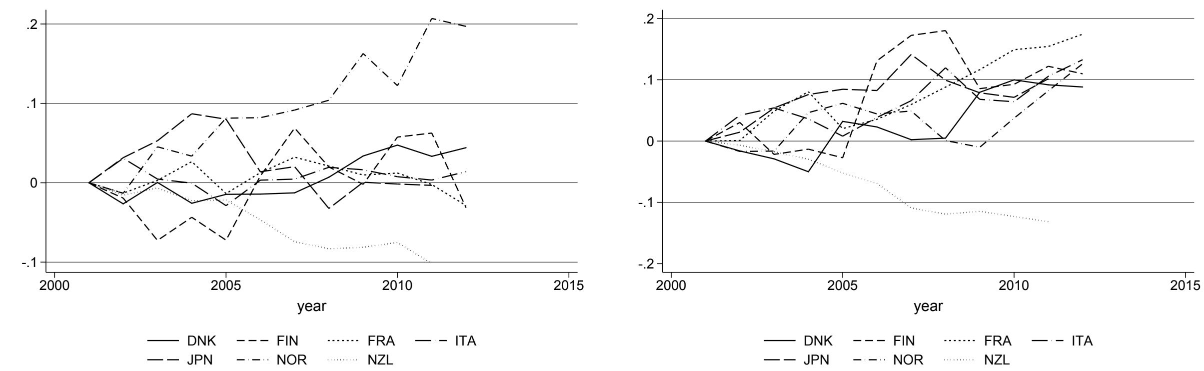
[19]The 12.3% figure is calculated as $100[exp(\beta_{2012}) - 1]$ where β_{2012} is the coefficient of the 2012 year dummy in equation 7. The detailed results of the regression are presented in Table A.1 in Appendix A.1.

[20]Note that in the rest of the paper we will use – for brevity sake – "wage dispersion" to indicate "between-firm wage dispersion" as the latter is the only type of dispersion we can calculate given the information available in MultiProd.

manufacturing and services the 90-10 wage ratio increased in most countries, with the exception of New Zealand, where it decreased significantly.[21]

Figure 2: Divergence of wages, by country

(a) Manufacturing **(b) Services**



Note: Change in the 90-10 difference of log wages (computed as the difference between the 90th and the 10th percentile of the log of real wages), respectively for manufacturing and services. The 90-10 difference is normalised at 0 in 2001 and averaged across 2-digit sectors weighted by employment. Countries with data starting after 2001 or for which data is only available at the macro-sector level are not included in this graphs; Hungary and the Netherlands are also excluded.

3.2.2 Evolution of dispersion at the top and at the bottom of the wage dispersion

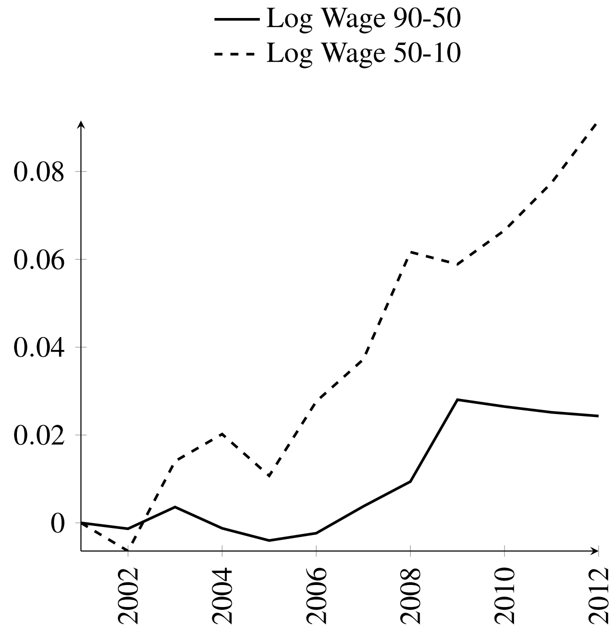
There has also been variation in the nature of the within-country wage divergence over time. An interesting question is whether the divergence is driven by an increasingly strong push outward at the top of the distribution, i.e. firms at the top increasingly paying more than the median firm, or whether firms at the bottom of the wage distribution are paying increasingly less relative to the median firm. To answer this question, we perform an exercise similar to the econometric approach of Equation (7) but separately for the 90-50 and the 50-10 log-wage differences. That is, we estimate econometrically the yearly average wage dispersion within countries and sectors, but separately for the top (90th-50th percentile ratio) and the bottom (50th-10th percentile ratio) of the wage distribution, to ascertain where the divergence was more pronounced.

Results, shown in Figure 3 and Figure 4, suggest that over the decade considered the divergence has been more severe at the bottom of the wage distribution *within each country-sector pair*. The divergence at the top has remained relatively stable in manufacturing over the whole period and in non-financial market services until 2006, when it grew significantly until 2009. Interestingly, the diverging patterns at the top and bottom of the wage distribution seem to have become increasingly different after the Great Recession, suggesting that workers in the lowest-paying firms might have disproportionally suffered in the aftermath of the crisis relative to workers in the median firm. At the same time dispersion

[21] In un-reported results obtained at the macro-sector level, we find that wage dispersion has decreased in Canada as well (data for Canada are not available at the 2 digit level). This result is reminiscent of the findings in Fortin and Lemieux (2015) who, using data from the 1997 to 2013 Labour Force Survey for Canada, show that overall wage inequality has decreased in a few Canadian provinces due to the extractive resources sector boom.

at the top of the distribution has declined after 2009, again suggesting that the workers in the tail of the distribution (in this case the highest paying firms) have lost their pay-advantage relative to workers in the median firm after the crisis. These two countervailing forces – compression at the top and increased dispersion at the bottom – are masked when looking at the 90-10 ratio, whose trend does not seem to be particularly affected by the Great recession (Figure 1).

Figure 3: Wage dispersion at the top versus bottom of the distribution



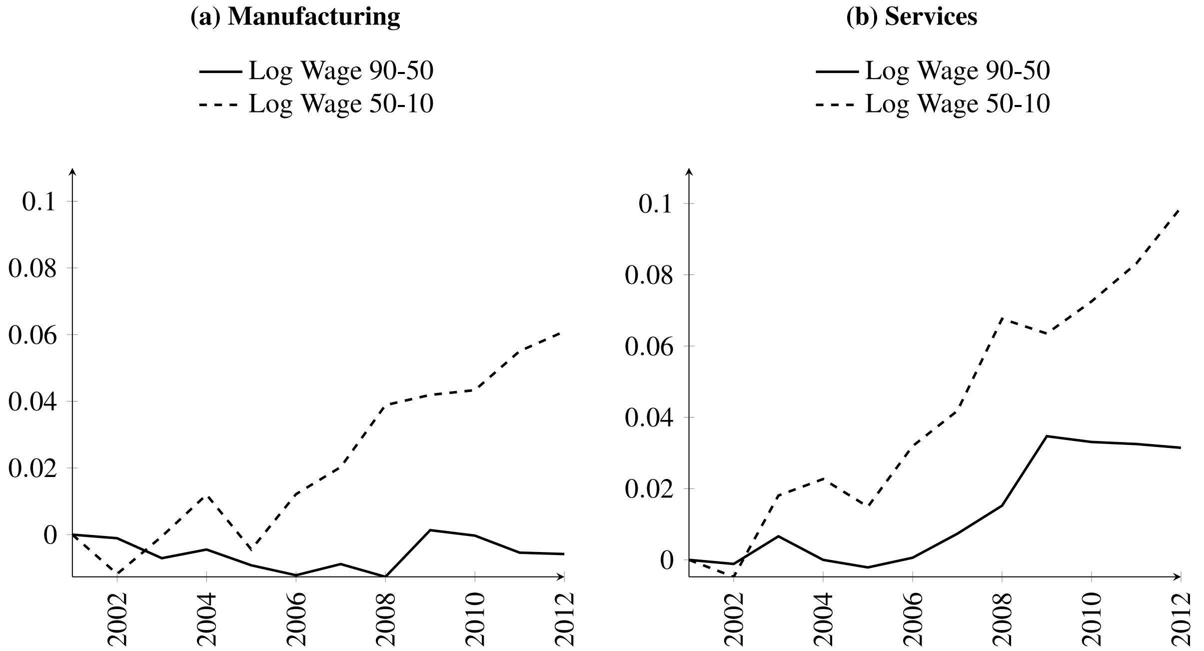
Note: The figure plots the year dummy estimates of a regression of log-wage dispersion at the top (90th and 50th percentiles difference) and at the bottom (50th and 10th percentiles difference) within country-sector pairs, using data from the following countries: AUS, AUT, BEL, CHL, DNK, FIN, FRA, HUN, ITA, JPN, NLD, NOR, NZL, SWE.

3.2.3 Cross-sectional wage dispersion

The literature has shown that the between-firm wage dispersion is particularly important to explain the overall change in wage inequality over time, and this is why our analysis focusses on the evolution of wage dispersion over time. Still, also our data display a substantial level of wage inequality even on the cross section, and the previous graphs clearly mask this fact since the dispersion in wages is indexed at zero at the beginning of the period.

Table 5 reports for 2001 the average 90-10 log wage differences across 2-digit sectors, separately for each country and for manufacturing and services. The magnitude of the spread between the top and bottom decile of the wage distribution gives us an insight into the inequality of wages, and the results show that the wage dispersion between firms within countries and sectors is clearly substantial. For instance, in manufacturing in 2001, wages in the highest paying firms, i.e. those at the 90th percentile of the wage distribution, were on average 3.4 times those at the bottom decile (an average log wage differential of 1.23). The spread is even more pronounced in non-financial market services, where the ratio is 5.8 for the average country (an average log wage differential of 1.76).

Figure 4: Wage dispersion at the top versus bottom of the distribution



Note: The figure plots the year dummy estimates of a regression of log-wage dispersion at the top (90th and 50th percentiles difference) and at the bottom (50th and 50th percentiles difference) within country-sector pairs, separately for manufacturing and services. Countries: AUS, AUT, BEL, CHL, DNK, FIN, FRA, HUN, ITA, JPN, NLD, NOR, NZL, SWE.

Table 5: 90-10 log wage difference in 2001

	90-10 log wage difference	
	Manuf.	Services
Denmark	1.07	1.53
Finland	1.08	1.98
France	1.05	1.41
Hungary	1.68	2.39
Italy	1.10	1.29
Japan	0.84	1.04
Netherlands	1.64	2.70
New Zealand	1.45	1.82
Norway	1.20	1.72

Note: 90-10 log wage difference, averaged across 2-digit sectors using employment as weights.

4. DIVERGENCE IN PRODUCTIVITY

In the previous section we have shown that over the last decade there has been a steady increase in wage dispersion, which can be attributed mostly to differences in pay across firms operating within the same sectors. Taking as a starting point the quote of Mortensen's work on wage inequality reported at the beginning of the report:

> Why are similar workers paid differently? Why do some jobs pay more than others? [...] wage dispersion of this kind reflects differences in employer productivity. [...] Of course, the assertion that wage dispersion is the consequence of productivity dispersion begs another question. What is the explanation for productivity dispersion?

We now look at whether the observed pattern in wage divergence is paralleled by a divergence in productivity within country-sectors during our sample period.

4.1 Productivity dispersion and its evolution over time

Table 6: 90-10 log productivity differences in 2001

	Log-LP 90-10 diff.		Log-MFP 90-10 diff.	
	Manuf.	Services	Manuf.	Services
Denmark	1.31	1.90	1.19	1.73
Finland	1.19	1.34	1.14	1.22
France	1.30	1.64	1.33	1.62
Hungary	2.45	3.09	2.38	2.83
Italy	1.71	1.93	1.65	1.77
Japan	1.13	1.25	1.02	1.21
Netherlands	1.86	2.69	2.34	2.89
New Zealand	1.93	2.15	1.94	2.00
Norway	1.52	1.96	1.67	1.94

Note: 90-10 log productivity differences, averaged across two-digit sectors using employment and log value-added as weights for labour productivity and MFP respectively.

The large dispersion in productivity even within narrowly defined industries is an established fact in the literature (e.g. Syverson, 2004). Table 6 revisits this fact for several countries and provides a simple descriptive account of the dispersion in productivity, measured as the difference between the 90^{th} and 10^{th} percentiles of the log productivity distribution. As expected, there is a rather significant dispersion in both manufacturing and services between the top and the bottom performing firms in terms of labour productivity (LP) and multi-factor productivity (MFP).[22] In 2001, on average across countries,

[22] Note that, in the case of labour productivity, the percentiles of the level and the log of LP are different due to the presence of negative value added firms. As standard in the literature, we analyse Log-LP and leave the investigation of the role of negative value added firms to future research. In a preliminary analysis we find that the share of this type of firms has increased during the crisis, and that for certain countries negative value added firms are a sizeable share of the total. By removing these firms from the sample, the current analysis could therefore underestimate the extent of the increase in productivity dispersion over the period.

firms in the top decile of the distribution can produce almost five times as much value added per worker as firms in the bottom decile in the same country's manufacturing sector, and more than seven times as much in services. When looking at (log) MFP, firms at the top of the distribution produce, with the same amount of measured inputs, more than five times the output of firms at the bottom of the distribution in manufacturing, and almost seven times in the service sector.[23]

The previous simple cross-country averages are silent on the changes that have taken place over time. However, as in the case of wages, the dispersion has actually increased substantially over time, a fact that has not received sufficient attention in the literature so far. So we now look at whether the observed increase in wage divergence is paralleled by a divergence in productivity within countries and sectors over the same period. Productivity divergence will have taken place within a country's sector if productivity for the group of most productive firms increased faster than it did for the least productive firms. To illustrate the trends in the relative productivity performance of top performers vs. laggards, Figures 5 and 6 plot the difference between the 90$^{\text{th}}$ and 10$^{\text{th}}$ percentiles of log-productivity (labour productivity and MFP, respectively) over time, normalised at 0 in 2001. In each figure, the left panel represents log-productivity dispersion in manufacturing and the right panel represents log-productivity dispersion in (non-financial) market services, where the patterns at the macro-sector level are obtained by country as averages across 2-digit sectors weighted by employment.

Figures 5 and 6 illustrate well the trend in log-productivity dispersion, which is increasing both in manufacturing and in services. For the majority of countries dispersion in 2012 is higher than in 2001: in services this is the case for all countries but New Zealand in terms of labour productivity; in manufacturing for all but Italy and New Zealand – both in terms of labour and multi-factor productivity.

As with the divergence of wages in Section 3, we need to ensure that the observed increase in productivity dispersion is not driven by changes in the underlying sample of countries and/or sectors. To analyse productivity divergence more rigorously, as we did for wages, we therefore estimate the following regression:

$$(\log P_{90} - \log P_{10})_{cjt} = \alpha + \beta_t y_t + z_{cj} + \varepsilon_{cjt} \quad (8)$$

where P_{90} and P_{10} are respectively the 90$^{\text{th}}$ and 10$^{\text{th}}$ productivity percentiles, for a given productivity measure P, and where c denotes countries, j sectors and t years. Year dummy estimates β_t capture the average within country-sector dispersion in a given year, and as such can be used to depict the evolution of productivity dispersion within countries-sectors over time.

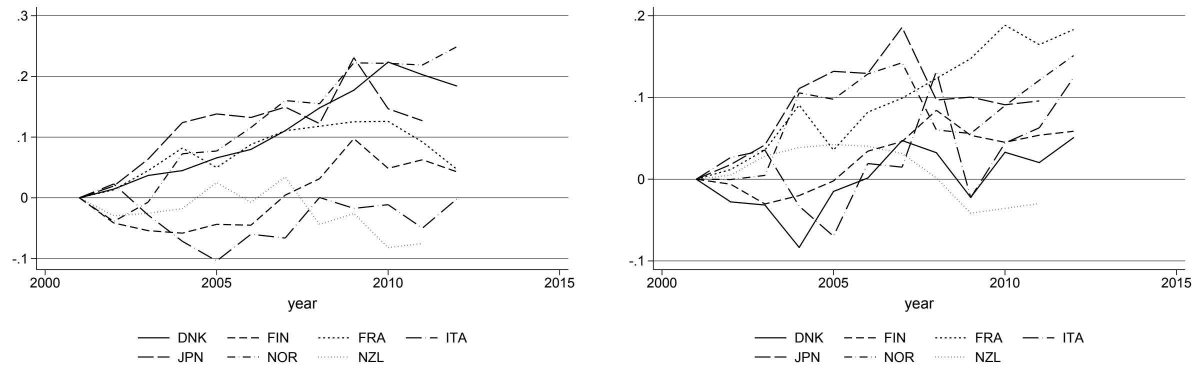
Figure 7 (on p. 24) shows that for both labour and multi-factor productivity, within-sector dispersion has increased over time on average across all countries.[24] The pattern is remarkably similar across all productivity measures, including the Solow-type MFP. And the growth in dispersion over the period is of the same magnitude as, if not higher than, the increase in wage dispersion. We can therefore speak of

[23]These figures are obtained by taking the exponential of the unweighted average across countries of the 90-10 log-productivity differences reported in the table; respectively 1.59 and 1.99 for LP, and 1.63 and 1.91 for MFP. These figures are in line with the estimates for the manufacturing sector reported, for example, in Syverson (2011).

[24]The exact regression results are given in Table A.2 in the Appendix.

Figure 5: Divergence of (log) Labour Productivity over time

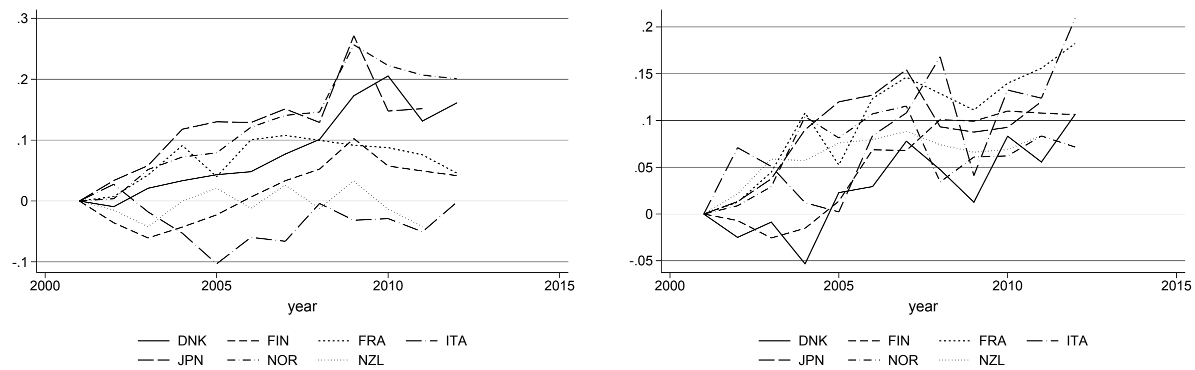
(a) Manufacturing **(b) Services**



Note: Change in 90-10 difference of log-labour productivity for manufacturing (left panel) and services (right panel). The 90-10 difference is normalised at 0 in 2001 and averaged across 2-digit sectors weighted by employment. Countries with data starting after 2001 or for which data is only available at the macro-sector level are not included in this graphs; Hungary and the Netherlands are also excluded.

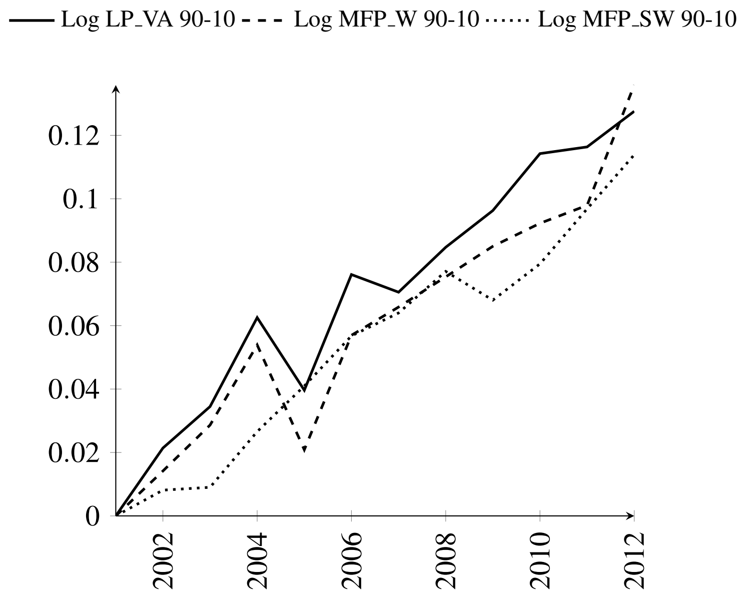
Figure 6: Divergence of (log) MFP over time

(a) Manufacturing **(b) Services**



Note: Change in the 90-10 difference of log-MFP (Wooldridge) for manufacturing (left panel) and services (right panel). The 90-10 difference is normalised at 0 in 2001 and averaged across 2-digit sectors weighted by log value-added. Countries with data starting after 2001 or for which data is only available at the macro-sector level are not included in this graphs; Hungary and the Netherlands are also excluded.

**Figure 7: The "Great Divergence" in productivity:
90-10 difference in log Productivity**



Note: The figure plots the year dummy estimates β_t of a regression of log-productivity dispersion (measured as the difference between the 90th and 10th percentiles of log-productivity) within country-sector pairs, using data from the following counntries: AUS, AUT, BEL, CHL, DNK, FIN, FRA, HUN, ITA, JPN, NLD, NOR, NZL, SWE.

the "Great Divergences" of both wages and productivity, and the very similar patterns they display over time call for an investigation of the potential concomitant forces that drive both phenomena (Section 5).

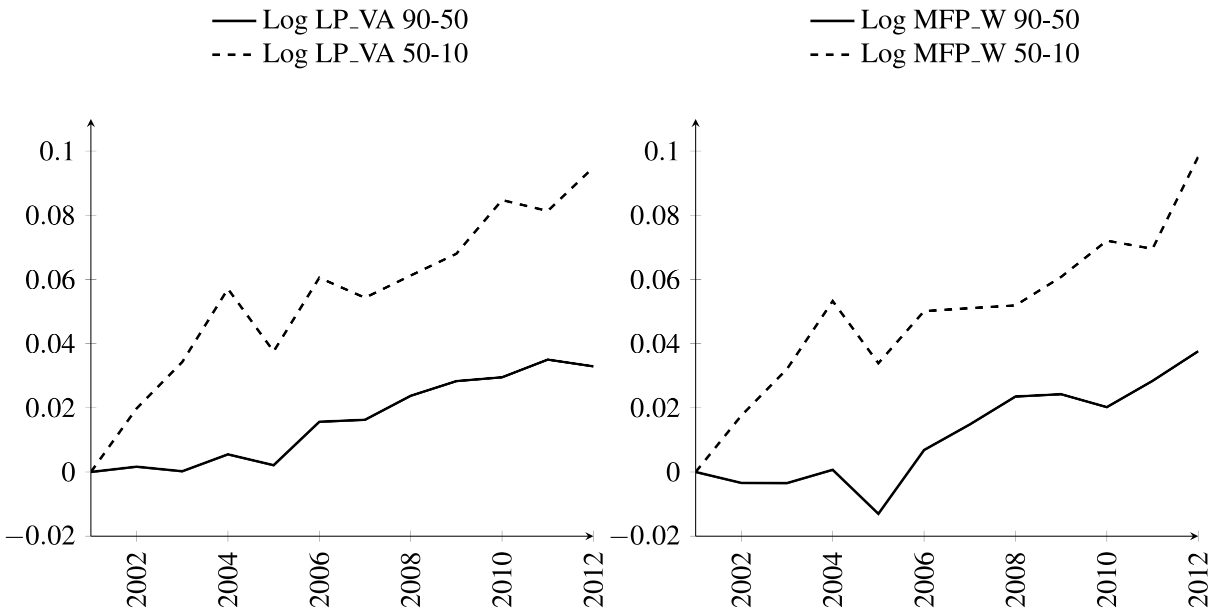
4.2 Evolution of productivity dispersion at the top and at the bottom of the distribution

An interesting question is whether productivity divergence is driven by an acceleration of frontier firms or by a slowing down of productivity at the bottom relative to the median firm. To answer this question, we estimate the yearly average productivity dispersion within countries and sectors, separately for the top 90-50 and bottom 50-10 differences of the log-productivity distribution.

The estimates, shown in Figure 8, suggest that the divergence has happened both at the top and at the bottom of the distribution. The dispersion at the top starts growing after 2005, slightly flattens out during the crisis years but increases again as of 2010. The gap between the median firm and firms in the bottom decile of the distribution has been steadily increasing since 2000 and, especially when focusing on trends in MFP dispersion, the crisis has widened the gap even further. Looking at the same pattern separately for manufacturing and services (Figure 9 and Figure 10), we see that the service sector behaves roughly as the aggregate figure given its large weight in the economy, but the manufacturing sector displays interesting differences. The dispersion at the top even decreases before 2005, and this pattern contributes significantly to the flat dispersion found in the aggregate economy; after 2005 the dispersion peaks up but to a lesser extent compared to services. The dispersion at the bottom still displays a higher growth over the period, but it is more volatile, especially for MFP.

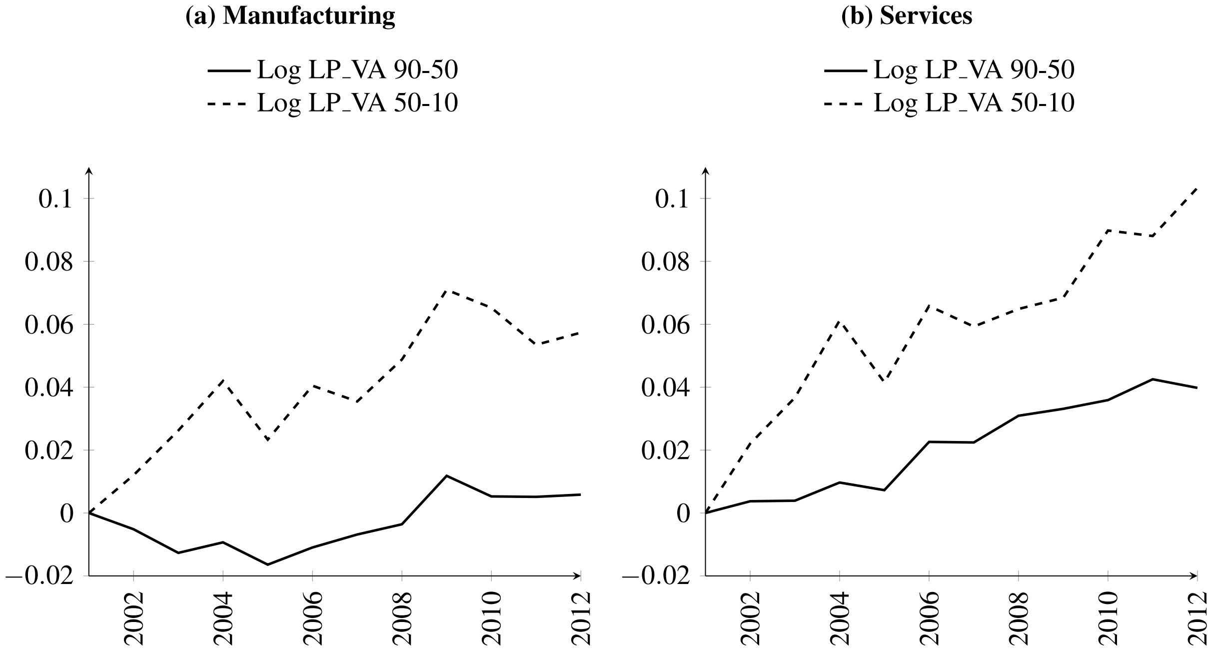
One of the main takeaways from Figure 8 is that the within-country sector divergence has been more severe at the bottom of the productivity distribution especially at the beginning of the 2000s and after the crisis; the divergence at the top has started picking up around the mid-2000s and between 2005 and the crisis shows an increasing trend similar to that of the bottom of the distribution leading to growing divergence overall. When thinking of what is driving the divergence at the bottom, there can be two forces at work: an increasing gap between the median and the worst performing firms might reflect a faster growth at the median relative to the bottom firms, but it could also reflect a worsening of the selection effect at the bottom of the distribution, with unproductive firms managing to remain in the market despite their low productivity. This would mean that the process of productivity enhancing resource reallocation has worsened since the early 2000s. Until the mid 2000s, median firms were gaining a productivity advantage relative to bottom performing firms and they were keeping up with the top performing firms. However, since the mid-2000s they have started losing ground vis-à-vis their national frontier firms, which have steadily become relatively more productive.

Figure 8: Productivity dispersion at the top versus bottom of the productivity distribution



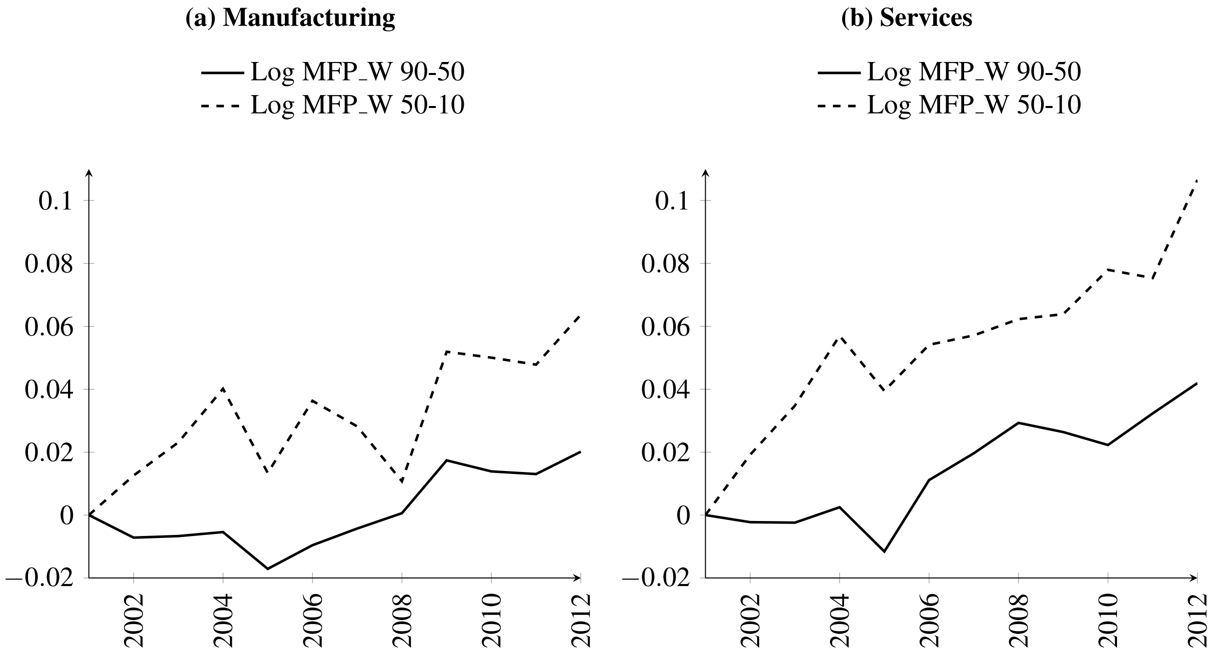
Note: The figure plots the year dummy estimates of a regression of log-LP_VA and log-MFP_W dispersion, respectively, at the top (90th and 50th percentiles ratio, solid line) and at the bottom (50th and 10th percentiles ratio, dashed line) within country-sector pairs. Countries: AUS, AUT, BEL, CHL, DNK, FIN, FRA, HUN, ITA, JPN, NLD, NOR, NZL, SWE.

Figure 9: Labour productivity dispersion at the top versus bottom of the productivity distribution, for manufacturing and services



Note: The figure plots the year dummy estimates of a regression of log-productivity dispersion at the top (90^{th} and 50^{th} percentiles difference, solid line) and at the bottom (50^{th} and 10^{th} percentiles difference, dashed line) within country-sector pairs, separately for manufacturing and services. Countries: AUS, AUT, BEL, CHL, DNK, FIN, FRA, HUN, ITA, JPN, NLD, NOR, NZL, SWE.

Figure 10: Log MFP_W dispersion at the top versus bottom of the productivity distribution, for manufacturing and services



Note: The figure plots the year dummy estimates of a regression of log-productivity dispersion at the top (90^{th} and 50^{th} percentiles difference, solid line) and at the bottom (50^{th} and 10^{th} percentiles difference, dashed line) within country-sector pairs, separately for manufacturing and services. Countries: AUS, AUT, BEL, CHL, DNK, FIN, FRA, HUN, ITA, JPN, NLD, NOR, NZL, SWE.

5. THE LINK BETWEEN WAGE INEQUALITY AND PRODUCTIVITY DISPERSION

The analysis of wages and productivity has enabled us to show two results: 1. heterogeneity in wages and productivity is significant, even between firms operating within the same sector; and 2. this heterogeneity has increased over time, a phenomenon we call the 'Great Divergence(s)'. In a well-functioning economy, wages should reflect the marginal productivity of workers, and as such should reflect firms' productivity. It is therefore legitimate to investigate whether the Great Divergence in wages and the Great Divergence in productivity are merely two sides of the same coin.

5.1 The correlation between wages and productivity

Before diving into the analysis of the forces that might affect the dispersion of wages and productivity, it is instructive to provide a more precise picture of their relationship.

First, Table 7 shows that productivity and wages are positively correlated at the firm level. Interestingly, the firm-level correlation are very similar across the manufacturing and the service sectors and whether the measure of productivity considered is labour or multi-factor productivity, with correlation coefficients ranging between 0.17 and 0.73 across countries. The table therefore confirms that firms with higher productivity levels tend to be also the ones that pay higher wages.[25]

Table 7: Firm-level correlation Wage-Productivity in 2001

	corr(W,LP)		corr(W,MFP)	
	Manuf.	Services	Manuf.	Services
Denmark	0.64	0.66	0.56	0.53
Finland	0.23	0.29	0.29	0.30
France	0.56	0.50	0.58	0.61
Hungary	0.48	0.30	0.60	0.49
Italy	0.42	0.36	0.51	0.48
Japan	0.72	0.73	0.63	0.61
Netherlands	0.46	0.53	0.51	0.56
New Zealand	0.20	0.17	0.47	0.44
Norway	0.49	0.50	0.61	0.58

Note: Firm-level correlation between wage and productivity, averaged across 2-digit sectors weighted by employment. Countries with data starting after 2001or for which data is only available at the macro-sector level are not included.

Second, we investigate how the link between wage and productivity dispersion changes across the distribution of productivity. The MultiProd data allow us to explore the relative strength of the correlation

[25] Appendix A.2 reports a more detailed analysis of the evolution of the correlation between wages and productivity within country sectors over time. Interestingly, the results show that while the correlation between wages and labour productivity has increased over time, the correlation between wages and MFP has steadily weakened until the crisis and has significantly increased only in recent years.

between wages and productivity at different quantiles of the productivity distribution, for both labour productivity and MFP. A strong and robust pattern emerges from the results displayed in Table 8: wages and productivity are less correlated at the tails of the distribution. The estimated coefficients for the bottom and the top decile of the productivity distribution are in fact negative relative to the baseline category, which is the centre of the distribution (fourth and fifth deciles). That seems to suggest that some sections of the productivity distribution encompass relatively more information about wages.

Table 8: Wage-productivity correlation by quantiles of productivity

LogLP_VA

	(1)	(2)
1.prod_percentile	-0.108***	-0.106***
	(0.008)	(0.024)
2.prod_percentile	0.108***	0.108***
	(0.004)	(0.017)
4.prod_percentile	0.104***	0.108***
	(0.002)	(0.013)
5.prod_percentile	-0.080***	-0.078***
	(0.004)	(0.021)
Observations	12626	12626
Adj. R-Square	0.366	0.648
Country-sector FE	NO	YES
Year FE	YES	YES
Nb Countries	10	10

The dependent variable is the firm-level correlation between wage and productivity.
Clustered standard errors at the country-sector level in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Countries: AUS AUT BEL DNK FIN HUN ITA JPN NLD NOR.

LogMFP_W

	(1)	(2)
1.prod_percentile	-0.109***	-0.090***
	(0.010)	(0.026)
2.prod_percentile	0.076***	0.085***
	(0.010)	(0.019)
4.prod_percentile	0.107***	0.103***
	(0.005)	(0.017)
5.prod_percentile	-0.045***	-0.031
	(0.010)	(0.025)
Observations	11838	11838
Adj. R-Square	0.245	0.663
Country-sector FE	NO	YES
Year FE	YES	YES
Nb Countries	10	10

The dependent variable is the firm-level correlation between wage and productivity.
Clustered standard errors at the country-sector level in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Countries: AUS AUT BEL DNK FIN HUN ITA JPN NLD NOR.

The channels behind the weaker correlation between wages and productivity might be very different at the top and at the bottom of the distribution. In addition, the weaker correlation might reflect firms paying too high or too low wages relative to their productivity level. The weaker correlation at the bottom might be driven by the fact that less productive firms might have to pay wages that are relatively too high compared to their productivity because of the existence of policies (e.g. minimum wage) that might weaken the link between average wages and productivity. It might also be the case that they pay wages that are excessively too low, given their productivity, because workers in these firms might be willing to accept excessively low wages (e.g. if they have no experience, are immigrants etc.). At the top it might be that competition for talents might push firms to pay excessively high wages relative to the productivity of workers (especially for managers), which would be in line with recent models of CEO pay (Gabaix and Landier, 2008). Alternatively, firms at the top of the productivity distribution might pay wages that do not fully reflect their productivity advantage, in line with the fact that most of the productivity gains of these top performers are not translated into wage gains for their workers, as suggested by the recent literature on decoupling between wages and productivity (e.g. Autor et al., 2017).

5.2 The link between growing wage inequality and increase in productivity dispersion

We now turn to investigate the main question of our report, namely whether wage dispersion is correlated with productivity dispersion. To examine this claim, we run the following regressions:

$$WD_{cjt} = \alpha + \beta \cdot PD_{cjt} + y_t + z_{cj} + \varepsilon_{cjt} \quad (9)$$

where WD_{cjt} denotes wage dispersion,[26] PD_{cjt} denotes productivity dispersion, z_{cj} and y_t indicate respectively country-sector and year fixed effects. Equation (9) relates wage dispersion to productivity dispersion controlling for year as well as country-sector fixed effects. It thus identifies the relationship between wage and productivity dispersions over time within each country-sector, controlling for overall time shocks. The estimates obtained using fixed-effects control for any unobserved time invariant country-sector specific factor, reducing the problem of omitted variables.[27]

In this regression the coefficient of interest is β. Table 9 reports the estimates of β using different measures of productivity. Column (1) reports the specification where productivity is measured by logged labour productivity; Column (2) reports estimates where the measure of productivity is logged MFP_W; and Column (3) reports estimates of regressions where MFP is a Solow residual (MFP_SW). Unsurprisingly, given the discussion in the previous subsection, the β estimates from the regression reported in Table 9 are positive and significant. The result suggests that there is a strong correlation between dispersion in wages and dispersion in productivity, for all the productivity measures considered.

More precisely, given the inclusion of fixed effects, the coefficients reported in Table 9 indicate a positive link between the evolution of wage dispersion and productivity dispersion within country-sectors. Specifically, an increase of one standard deviation in the dispersion of logged labour productivity correlates with an increase of logged wage dispersion by 35.8%, a coefficient that is positive and statistically different from zero. In Column (2) an increase of one standard deviation in the dispersion of logged MFP_W corresponds to a statistically significant increase of 22.4% in wage dispersion; at 4.7%, the effect is smaller for the dispersion of MFP_SW (Column 3) but still significant at the 10% level.

These results suggest that sectors in which the distribution of productivity becomes more polarised over time are also sectors in which wages polarise. Results in the previous two sections have shown that the dispersion has grown faster at the bottom of the distribution, both for wages and productivity. It is therefore interesting to explore whether the different dynamics at the top and bottom of the wage and productivity distributions also impact the link between the two. In order to do this, we regress wage dispersion at the top (90th-50th percentile ratio) on productivity dispersion at the top (90-50 ratio); and similarly for the the bottom of both distributions (50-10 ratios). Results given in Table 10 suggest that the link between wage and productivity dispersions exists both at the top (columns 1 to 3) and the bottom of the distributions (columns 4 to 6); further, this link is tighter at the bottom for labour produc-

[26] More precisely: $WD_{cjt} \equiv \left(\log \frac{W_{90}}{W_{10}}\right)_{cjt}$, the 90-10 percentile ratio of log wages.

[27] In Section 5.3, we run the same specification including additional time-varying controls.

Table 9: Regressing wage dispersion on productivity dispersion (country-sector fixed effects)

	(1) log Wage (90-10)	(2) log Wage (90-10)	(3) log Wage (90-10)
log LP (90-10)	0.358*** (0.069)		
log MFP_W (90-10)		0.224** (0.058)	
log MFP_SW (90-10)			0.047* (0.040)
N	3739	3624	3712
Adj. R-Square	0.987	0.986	0.986
Year FE	YES	YES	YES
Country-sector FE	YES	YES	YES
Nb Sectors	22	22	22
Nb Countries	14	14	14

Standardised beta coefficients; Errors are clustered at the country-sector level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Countries: AUS, AUT, BEL, CHL, DNK, FIN, FRA, HUN, ITA, JPN, NLD, NOR, NZL, SWE.

Table 10: Regressing wage dispersion on productivity dispersion (country-sector fixed effects), separately for top and bottom halves of the distribution

	(1) log Wage (90-50)	(2) log Wage (90-50)	(3) log Wage (90-50)	(4) log Wage (50-10)	(5) log Wage (50-10)	(6) log Wage (50-10)
log LP (90-50)	0.411*** (0.103)					
log MFP_W (90-50)		0.409*** (0.098)				
log MFP_SW (90-50)			0.012 (0.021)			
log LP (50-10)				0.585*** (0.120)		
log MFP_W (50-10)					0.420*** (0.069)	
log MFP_SW (50-10)						0.084* (0.085)
N	3778	3657	3749	3746	3627	3731
Adj. R-Square	0.988	0.986	0.984	0.968	0.962	0.961
Year FE	YES	YES	YES	YES	YES	YES
Country-sector FE	YES	YES	YES	YES	YES	YES
Nb Sectors	22	22	22	22	22	22
Nb Countries	14	14	14	14	14	14

Standardised beta coefficients; Errors are clustered at the country-sector level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Countries: AUS, AUT, BEL, CHL, DNK, FIN, FRA, HUN, ITA, JPN, NLD, NOR, NZL, SWE.

tivity and MFP_SW. MFP_W displays a correlation that is roughly the same between the bottom and the top of the distributions.

5.3 Robustness checks

To confirm the robustness of the estimates of Equation (9), we add additional controls to alleviate potential biases of omitting relevant time-varying variables in our estimation. That is, we run the following regression:

$$WD_{cjt} = \alpha + \beta \cdot PD_{cjt} + \boldsymbol{X}'_{cjt}\gamma + \boldsymbol{y}_t + \boldsymbol{z}_{cj} + \varepsilon_{cjt} \quad (10)$$

where $\boldsymbol{X}$ denotes time-varying controls.

Table 11: Regressing wage dispersion on productivity dispersion (country-sector fixed effects), with controls

	(1) log Wage (90-10)	(2) log Wage (90-10)	(3) log Wage (90-10)	(4) log Wage (90-10)	(5) log Wage (90-10)	(6) log Wage (90-10)
log LP (90-10)	0.288***			0.254***		
	(0.081)			(0.081)		
log MFP_W (90-10)		0.221*			0.195+	
		(0.058)			(0.054)	
log MFP_SW (90-10)			0.074*			0.065*
			(0.038)			(0.036)
% hrs by skilled workers	-0.201*	-0.165	-0.156	-0.108	-0.075	-0.065
	(0.407)	(0.430)	(0.430)	(0.316)	(0.337)	(0.332)
Log Mean of age (unweighted)				0.059**	0.058**	0.055*
				(0.025)	(0.025)	(0.025)
N	2265	2191	2250	1786	1711	1771
Adj. R-Square	0.970	0.969	0.969	0.976	0.975	0.975
Year FE	YES	YES	YES	YES	YES	YES
Country-sector FE	YES	YES	YES	YES	YES	YES
Nb Sectors	22	22	22	22	22	22
Nb Countries	11	11	11	9	9	9

Standardised beta coefficients; Errors are clustered at the country-sector level: $^{+}$ $p < 0.13$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Countries: AUS, AUT, BEL, DNK, FIN, FRA, HUN, ITA, JPN, NLD, SWE.

The most obvious element that could affect the wage distribution is the quality of the workforce. Columns (1), (2) and (3) of Table 11 show the estimates for β when controlling for sectoral skill composition. The estimates remain positive and significant, despite the smaller sample size.[28] This suggests that the joint polarisation of wages and productivity over time still holds when accounting for changes in the composition of the labour force. Interestingly, the estimated coefficient on the skill share is negative (although not robustly significant), which suggests that increases in the share of high skills in a sector are linked to a decrease in wage dispersion. Taken at face value, this would imply that increasing the workers' skills, in terms of quantity and/or quality, might be a potential avenue for containing wage inequality.

In addition to skills there might be other factors that might drive both wage and productivity dispersions. We also control for differences in the firm age composition, in order to exploit differences in

[28]The data on skills are not available for Chile, Norway and New Zealand; they are ISIC Revision 4 estimates based on the ISIC 3 original data from the World Input Output Tables (WIOD), Socio Economic Accounts, July 2014 (See Timmer et al., 2015).

business dynamism across sectors (see Aghion et al., 2009, for the role of entry in the increase in inequality and Decker et al., 2016, for the link between business dynamism and productivity dispersion).[29] Unfortunately the sample size is further reduced to only nine countries because this control is not available for the whole sample, but the results, reported in columns (4) to (6) of Table 11, show that the correlations between wage and productivity dispersions are relatively robust to including this additional control. The correlation between wage and MFP_W dispersion is the one mostly affected and is now significant only at the 13% level. In Section 6 we explore in more detail the role of structural changes in explaining wage and productivity divergence and their correlation, while we report additional results in Appendix A.5.

6. A FIRST INVESTIGATION OF THE DRIVERS OF THE GREAT DIVERGENCE(S)

In the previous sections we have looked at the divergence in wages and productivity within sectors and countries. In this section, we investigate the role of structural factors as well as policies and institutional features of the economy that might have strengthened or weakened the correlation between wage and productivity dispersion.

6.1 Divergence and structural factors

As discussed in the introduction of the report, we start by exploring the role of increased globalisation and digitalisation of the economy. This first attempt is limited by the availability of data on these two phenomena both in terms of country and sectoral coverage, but also in their capacity of capturing these phenomena in their entirety. Tables 12 and 13 try to capture trends in sectors' globalisation by controlling for changes in imports and exports of goods, and in the sector openness, measured as the sum of imports and exports (in logs). Moreover we seek to investigate the role of digitalisation by including the share of ICT in gross non-residential fixed assets. Finally, to try to capture skill-biased technical change in a different way, we include as regressor the share of hours worked by high skilled workers.[30] Table 12 shows the results for labour productivity and Table 13 for MFP. As before all regressions include country by sector and year fixed effects, so they investigate the impact of structural changes on changes in the dispersion of wages within country-sectors over time. Unfortunately the sample is regression specific due to limited information on structural factors, for instance trade data are available only for manufacturing.

The results indicate that the correlation between wage and productivity dispersion remain strong even after controlling for these structural changes, which also significantly affect wage dispersion. More

[29] It is also possible to control for market sectors, using the Herfindahl-Hirschman index of gross output, computed from firm-level data. Unsurprisingly this weakens the correlation between wage dispersion and productivity dispersion, since mechanically, more concentrated sectors will mechanically display less productivity dispersion.

[30] Trade data come from the OECD STAN Bilateral Trade Database by Industry and End-use category (BTDIxE), while the ICT data from the OECD Annual National Accounts, ISIC Revision 4. Further information and details are available on http://stats.oecd.org. The data on skills are ISIC Revision 4 estimates based on the ISIC 3 original data from the World Input Output Tables (WIOD), Socio Economic Accounts, July 2014 (See Timmer et al., 2015).

Table 12: Divergences and structural factors (LP)

	(1)	(2)	(3)	(4)	(5)	(6)
Log LP (90-10)	0.187***	0.170***	0.179***	0.191***	0.165***	0.059*
	(0.040)	(0.042)	(0.041)	(0.037)	(0.046)	(0.031)
Log Import (goods)	-0.020					
	(0.060)					
Log LP (90-10) × Log Import (goods)	0.060***					
	(0.016)					
Log Export (goods)		0.051				
		(0.066)				
Log LP (90-10) × Log Export (goods)		0.086***				
		(0.021)				
Log Openness			0.021			0.029
			(0.066)			(0.045)
Log LP (90-10) × Log Openness			0.075***			0.041**
			(0.017)			(0.020)
Sh. of ICT in fixed assets				0.106*		0.099*
				(0.055)		(0.054)
Log LP (90-10) × Sh. of ICT in fixed assets				0.033*		0.046**
				(0.018)		(0.022)
Sh. high-skilled (in total hours)					-0.074	
					(0.050)	
Log LP (90-10) × Sh. high-skilled (in total hours)					0.076***	
					(0.020)	
N	1817	1817	1817	2003	2263	1089
Adj. R-Square	0.926	0.927	0.927	0.966	0.972	0.948
Country-sector year FE	YES	YES	YES	YES	YES	YES
Num. Countries	12	12	12	8	11	8

Clustered standard errors at the country-sector level in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The dependent variable is Log Wage (90-10), all regressors are standardised and the coefficients can be interpreted as the effect at the mean.

All regressions include the logarithm of total gross output in the sector as extra control.

The largest set of countries include: AUS AUT BEL DNK FIN FRA HUN ITA JPN NLD NOR SWE.

Table 13: Divergences and structural factors (MFP)

	(1)	(2)	(3)	(4)	(5)	(6)
Log MFP_W (90-10)	0.802***	0.795***	0.810***	0.351**	0.171*	0.664***
	(0.132)	(0.125)	(0.128)	(0.143)	(0.100)	(0.147)
Log Import (goods)	0.073					
	(0.061)					
Log MFP_W (90-10) × Log Import (goods)	0.290***					
	(0.053)					
Log Export (goods)		0.191**				
		(0.078)				
Log MFP_W (90-10) × Log Export (goods)		0.402***				
		(0.071)				
Log Openness			0.149**			0.092*
			(0.070)			(0.048)
Log MFP_W (90-10) × Log Openness			0.355***			0.215***
			(0.059)			(0.052)
Sh. of ICT in fixed assets				0.139**		0.074
				(0.063)		(0.057)
Log MFP_W (90-10) × Sh. of ICT in fixed assets				0.028		0.048
				(0.091)		(0.097)
Sh. high-skilled (in total hours)					-0.057	
					(0.049)	
Log MFP_W (90-10) × Sh. high-skilled (in total hours)					0.042	
					(0.060)	
N	1779	1779	1779	1917	2190	1051
Adj. R-Square	0.919	0.922	0.921	0.962	0.969	0.946
Country-sector year FE	YES	YES	YES	YES	YES	YES
Num. Countries	12	12	12	8	11	8

Clustered standard errors at the country-sector level in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The dependent variable is Log Wage (90-10), all regressors are standardised and the coefficients can be interpreted as the effect at the mean.

All regressions include the logarithm of total gross output in the sector as extra control.

The largest set of countries include: AUS AUT BEL DNK FIN FRA HUN ITA JPN NLD NOR SWE.

importantly for our analysis, the estimates suggest that both of the structural factors analysed, globalisation and digitalisation, seem to strengthen the correlation between wages and productivity dispersion, resulting in a stronger increase of wage inequality when the dispersion of productivity increases. In the case of MFP, exports seem to have quite a strong link with wage dispersion both directly and via an increased correlation with productivity. The positive association between exports and between-firm wage inequality is in line with the existing evidence on the role of trade on wage inequality based on matched employer-employee data of single countries: for example Baumgarten (2013), focusing on Germany, find that exporting contributes significantly to increased between-firm wage dispersion even after controlling for importing and for proxies of ICT use. Similar evidence on the positive contribution of trade to wage inequality (at low levels of openness) is found by Helpman et al. (2017) for Brazil.

In a horse race regression where we include ICT and openness at the same time (column 6), the latter comes out stronger when looking at MFP; while ICT remains significant only when considering LP. In fact, in the case of labour productivity, ICT has the strongest direct link with wage dispersion, as well as a significant although smaller effect via a tighter link between wage and productivity dispersion. Interestingly, ICT does not seem to increase the correlation between MFP and wage dispersion; this result can be rationalised by the fact that MFP is already controlling for the increase in (ICT) capital. The share of high-skill in total hours worked is linked to an increase of the correlation between LP and wages, suggesting that sectors that become more skill intensive over time will also tend to experience a stronger connection between productivity and wage dispersion. This result is not robust in case of MFP, possibly highlighting a complementarity between high skills and capital, which is already captured by MFP. On the other hand the point estimate of the direct effect of high skills remains negative as in the estimates discussed in the previous section, confirming that sectors that have increased their share of high skilled workers have experienced a decrease in wage dispersion, but again not very significant.

6.2 The role of policies

Policies and regulations within countries may also shape the wage and productivity distributions and how they have changed over time. The data collected through the MultiProd project matched with information on framework conditions in different countries allow us to shed light on these important questions.

Some institutions, such as union coverage or level of bargaining, might be particularly relevant not only for understanding trends in wage inequality but also for the way they may affect the relationship between wage and productivity dispersion (see for example Gürtzgen, 2009, for a nice overview). Policies might have heterogeneous impact on wages and their correlation with productivity depending of whether workers are employed by high or low-productivity (and low-pay) firms. As discussed in Section 2, the MultiProd data contain information on the wage-productivity correlation by segments of the productivity distribution. This detailed information will offer a direct way of analysing the relationship between wages and productivity for firms characterised by different productivity levels, thus offering further evidence on the channels that link policy, wages and productivity.

Moreover policies might also counteract some of the effects that structural factors have on wages and productivity. Recent analyses of the impact of globalization on wage inequality in countries such as Sweden (Akerman et al., 2013), Germany (Baumgarten, 2013), and France (Carluccio et al., 2015), all recognise the importance of bargaining regimes in shaping the effect of trade on wages. In fact, cross-country differences might reflect differences in labour market institutions, and the extent to which these institutions might dampen the between-firm wage differences and might affect the decoupling between changes in the productivity and the wage distributions (OECD, 2016).

Finally the bargaining regime might matter also because some decoupling between productivity and wages can be observed when the effective length, breadth and regional coverage of collective bargaining agreement is very long and thus might weaken the actual link between productivity and wages. If the link between wages and productivity is broken, it becomes more difficult for resources to be allocated efficiently both across industries and across firms within industries. Conversely if wages and productivity move in the same direction, it is more likely that less productive firms shrink and their resources are allocated to firms at the top.

Countries that attempt to shield workers during adverse market conditions may feature less wage and productivity dispersion. On the one hand, this is of course beneficial to the workers as their jobs and salaries would be better protected and shielded by the cycles. Since workers are generally more risk adverse this may be welfare improving in the short run and, in addition, such regulations would also support equity amongst workers during the economic cycle. On the other hand, less dispersion in wages and productivity due to regulations may actually inadvertently impact aggregate productivity by distorting the flow of resources from less to more productive firms. Thus, policies that might be welfare improving in the short-run may have a detrimental impact in the long run: policies that hinder the reallocation of resources away from poorly performing to highly productive firms can result in slower aggregate productivity growth.

There are other aspects of this relationship that are worth considering. If economic policies play a role in shaping the wage distribution, one might expect that they will have a differential impact across segments of the productivity distribution. For example, in a country with a high minimum wage, one might expect the wage dispersion of the bottom quantile of the productivity distribution to be more compressed in comparison to countries with no or low minimum wages. On the other hand, the variance at the top quantile could be quite similar, since employees there earn higher wages in the first place. The shape of the overall wage distribution might then be just the result of a compression from the firms at the bottom while firms at the top of the distribution might not display any significant change in their wage policy.

In a nutshell we would like to understand whether country-specific policies affect wage dispersion and its link with productivity dispersion. To do so, we consider four main policies or institutional features of a country: i) minimum wage (both in terms of hourly real minimum wage and the minimum relative to average wages of full-time workers); ii) employment protection legislation (strictness of employment protection for both individual and collective dismissals); iii) trade union density and; iv) coordination in wage setting.[31,32] We run a first set of regressions in which we regress wage dispersion on productivity dispersion, the specific policy and their interaction. What we want to test is the direct effect of policies on wage dispersion as well as whether they strengthen or weaken the link of wage dispersion and productivity.

Table 14 shows the results of the exercise in the case of MFP.[33] The first four columns report estimates when looking at minimum wage (columns 1 and 2 using hourly real minimum wage and columns 3 and 4 using minimum wage relative to average wage in the country sector year); columns 5 and 6 look at employment protection legislation; estimates of trade union density can be found in columns 7 and 8 and estimates of coordination in wage setting can be found in columns 9 and 10. Each regression is run with two sets of fixed effects: first we only include year fixed effects to analyse the cross-sectional relationship controlling for overall macroeconomic shocks, captured by year dummies, reported in columns 1, 3, 5, 7, and 9; secondly, we include a full set of country-sector and year fixed effects to control for any country-sector specific unobservable factor and focus on the within sector country variation over time, reported in columns 2, 4, 6, 8, and 10.

The results show that the link between wage and productivity dispersion is not broken by the considered policies and still displays a robust positive sign. The policies have the intended consequence of reducing wage dispersion and hence overall inequality. At the same time they tend to significantly affect the link between wage and productivity dispersion. An interesting result, reported in the first four columns, is that the minimum wage seems to have different effects in the cross-section and over time: the link with lower wage inequality is stronger over time. The sign of the interaction term between minimum wage and productivity dispersion which is negative in the cross-section becomes positive when looking at variation within sectors and countries over time.

This result seems to suggest that those countries that have a higher minimum wage are also the ones that have a weaker link between wage and productivity dispersion. At the same time increases in the minimum wage, both in real and relative terms, are associated with a stronger correlation between wage and productivity dispersions, partially undoing the wage compression coming from the direct effect. A few explanations could rationalise this result: i) the exit of firms at the bottom of the productivity distribution; ii) an improvement in firms' performance (higher efficiency and/or higher innovation) in an environment characterised by higher labour costs; iii) a reduction in labour inputs (head counts or hours worked), a substitution of labour with capital, and/or a change in the composition of the workforce towards more productive workers, which again would result in productivity improvements over time.

[31] Note that we might not be able to fully capture the effects of policies that target more directly workers (e.g. minimum wage) rather than the firm (e.g. EPL) in terms of implications for both wages and labour mobility. This is because we only have average wage at the firm level which does not allow us to look at employees' tenure, skill composition within the firm etc ...

[32] The data on minimum wage and EPL come from OECD Stats, further information on the detailed national sources is available on http://stats.oecd.org. Trade union density is the ratio of wage and salary earners that are trade union members, divided by the total number of wage and salary earners; the data on trade union members are from the the ICTWSS database (Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts, release 3.0), while the number of workers are from the OECD Labour Force Statistics. Coordination in wage setting identifies the extent to which institutional features of wage setting arrangements are likely to generate more or less coordination (on a scale from 1 to 5, where 1 corresponds to 'Fragmented wage bargaining, confined largely to individual firms or plants' and 5 to 'Maximum or minimum wage rates/increases based on centralised bargaining') and comes from the ICTWSS database, release 5.0, November 2015.

[33] Table A.16 in the Appendix presents the results in terms of labour productivity.

Table 14: Divergences and Policy (MFP)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log MFP_W (90-10)	0.467***	0.075*	0.494***	0.063	0.622***	0.437**	0.064	0.370***	0.757***	0.285**
	(0.074)	(0.043)	(0.062)	(0.041)	(0.173)	(0.173)	(0.130)	(0.121)	(0.082)	(0.121)
Real Min Wage (hour)	-0.016	-0.369***								
	(0.028)	(0.077)								
Log MFP_W (90-10) × Real Min Wage (hour)	-0.139**	0.054*								
	(0.069)	(0.028)								
Relative Min Wage (wrt av)			-0.093*	-0.124***						
			(0.049)	(0.038)						
Log MFP_W (90-10) × Relative Min Wage (wrt av)			-0.135**	0.059***						
			(0.063)	(0.020)						
EPL (indiv. and coll.)					-0.106	-0.091**				
					(0.075)	(0.036)				
Log MFP_W (90-10) × EPL (indiv. and coll.)					-0.546*	-0.152				
					(0.316)	(0.107)				
Trade union density							-0.093	-0.361***		
							(0.093)	(0.062)		
Log MFP_W (90-10) × Trade union density							-0.688**	0.016		
							(0.281)	(0.085)		
Wage Setting									-0.081*	-0.103***
									(0.042)	(0.021)
Log MFP_W (90-10) × Wage Setting									-0.832***	-0.132***
									(0.130)	(0.050)
N	1804	1804	1804	1804	3456	3456	3456	3456	3456	3456
Adj. R-Square	0.662	0.970	0.656	0.967	0.296	0.966	0.346	0.968	0.486	0.966
Year FE	YES		YES		YES		YES		YES	
Country-sector year FE		YES		YES		YES		YES		YES
Num. Countries	7	7	7	7	13	13	13	13	13	13

Clustered standard errors at the country-sector level in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The dependent variable is Log Wage (90-10), all regressors are standardised and the coefficients can be interpreted as the effect at the mean.

The largest set of countries include: AUS AUT BEL DNK FIN FRA HUN ITA JPN NLD NOR NZL SWE.

To further investigate this channel, we look at the link between firm-level wages and productivity in each of the quantiles of the productivity distribution and at how the minimum wage affects this link at the different level. To do so, we regress the correlation between firm-level wages and productivity computed at the sector-year-productivity quantile level on dummies for each of the productivity quantiles and their interaction with the value of minimum wage relative to the average wage in the country sector year. Table 15 shows the results of this exercise, which is performed as before with two sets of fixed effects. The correlation displays the same pattern across quantiles already seen in Table 8: it tends to be weaker at the bottom and at the top of the productivity distribution. Moreover the table shows that a higher minimum wage weakens the correlation between wages and productivity across the whole productivity distribution, with the exception of the top quantile where the the effect is significantly smaller (for MFP), if present at all (for LP). When we analyse the within country-sector results and consider only the within variation (Columns 2 and 4), this effect tends to disappear. This is particularly true at the top of the productivity distribution, where an increase of the minimum wage over time actually tends to significantly strengthen the correlation between wages and productivity. This pattern holds true for both labour productivity (columns 1 and 2) and MFP (columns 2 and 4).

Analysing the other policies, a higher employment protection legislation is associated with a decrease in wage dispersion as well as a weaker link with productivity. This is true both for the cross-section and over time, although with different levels of significance. The same result applies to trade union density: a higher union density is associated with lower wage dispersion and with a weaker link between productivity and wage dispersion. It is interesting to note that the same pattern applies to both EPL and trade union density: they both significantly affect the link between productivity and wage dispersion in the cross-section, but not so much within country-sectors over time, where only the direct effect on wage dispersion appears to be significant. Controlling for time invariant country-sector characteristics, the two policies therefore seem to have the intended consequence of reducing wage dispersion, and even better without affecting the link between productivity and wages, or at least not significantly so.

The measure of coordination in wage setting is significant and negative both directly and when interacted with productivity, and both in the cross section and within country-sectors over time. This policy measure captures the extent to which wage setting arrangements are likely to generate more or less coordination, whereby the lowest level indicates that the wage bargaining is fragmented and confined largely to individual firms or plants while the highest level corresponds to centralised bargaining (with or without government involvement). Hence more centralised bargaining helps limiting the extent of wage dispersion, but at the same time weakens the link between wages and productivity, which might be detrimental for long run growth.[34]

[34]Manasse and Manfredi (2014) discuss how the collective bargaining system in Italy might be the cause of the misalignment between productivity and wages.

Table 15: Wage-productivity correlation and policy by quantiles of productivity

	(1) Corr W&LP_VA	(2) Corr W&LP_VA	(3) Corr W&MFP_W	(4) Corr W&MFP_W
Prod Perc 0-10	-0.072***	-0.067**	-0.085***	-0.083*
	(0.006)	(0.023)	(0.006)	(0.038)
Prod Perc 10-40	0.093***	0.097**	0.082***	0.083**
	(0.005)	(0.032)	(0.005)	(0.024)
Prod Perc 60-90	0.109***	0.110***	0.104***	0.100***
	(0.005)	(0.016)	(0.008)	(0.017)
Prod Perc 90-100	-0.099***	-0.102***	-0.025	-0.019
	(0.005)	(0.022)	(0.015)	(0.015)
Prod Perc 0-10 × Relative Min Wage (wrt av)	-0.093***	-0.021	-0.064***	-0.029
	(0.006)	(0.017)	(0.006)	(0.028)
Prod Perc 10-40 × Relative Min Wage (wrt av)	-0.079***	-0.010	-0.042***	-0.010
	(0.006)	(0.021)	(0.006)	(0.009)
Prod Perc 40-60 × Relative Min Wage (wrt av)	-0.057***	0.005	-0.045***	-0.014
	(0.005)	(0.008)	(0.004)	(0.016)
Prod Perc 60-90 × Relative Min Wage (wrt av)	-0.102***	-0.038	-0.061***	-0.025**
	(0.008)	(0.018)	(0.004)	(0.009)
Prod Perc 90-100 × Relative Min Wage (wrt av)	-0.005	0.056**	-0.018*	0.051**
	(0.007)	(0.015)	(0.010)	(0.012)
N	5531	5531	5085	5085
Adj. R-Square	0.469	0.626	0.307	0.536
Year FE	YES		YES	
Country-sector year FE		YES		YES
Num. Countries	5	5	5	5

Clustered standard errors at the country-sector level in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The dependent variable is the correlation between wages and productivity.

All regressors are standardised and the coefficients can be interpreted as the effect at the mean.

The largest set of countries include: AUS BEL HUN JPN NLD.

7. CONCLUSIONS AND NEXT STEPS

The last decades have seen a growing divergence in wages and productivity. Most of the existing evidence has documented these two trends separately, and often using evidence from a single country. In this report we attempt to contribute to this literature exploiting a novel data set that contains harmonised micro-aggregated statistics for 16 countries over the last fifteen years on productivity and wage dispersion, based on the OECD MultiProd project. Thanks to this unique data source we have been able to provide a detailed accounting of the evolution of wage and productivity dispersion and the link between the two. By linking the database to information on structural factors, such as ICT intensity and openness, as well as policies and institutions that affect the pay settings environment, such as minimum wage and unionisation, we can look at how these policies affect the link between productivity and wage dispersion.

We can summarise the findings of the report in five main takeaways:

1. Between-firm wage dispersion is found to be significantly and positively correlated to the overall wage dispersion and its evolution over time. Most of the between-firm wage variance is driven by differences in pay across firms within sectors rather than by differences in average wages across sectors. There has been a steady increase in wage inequality, measured as the 90-10 wage ratio, driven mainly by an increased dispersion at the bottom of the distribution; the dispersion at the top plays a role only in the service sector after 2005.

2. Similarly, we find that dispersion in productivity, whether measured as real value added per worker (labour productivity) or as multi-factor productivity (MFP), has also significantly increased in the last decades. Most of the increase is driven by within-sector productivity differentials across firms, rather than by cross-sectoral differences. Similar dynamics of increase at the bottom throughout the whole period and at the top only after 2005 are also present in the productivity data, which might point to a link between the co-evolution of wage and productivity dispersion.

3. The evidence suggests that wage dispersion is linked to increasing differences between high and low productivity firms, even controlling for sectors' skill composition. This relationship holds in levels and when looking at short- and long-term changes over time. Moreover, firm-level correlation between wages and productivity is systematically weaker at the top and at the bottom of the productivity distribution.

4. When looking at the role of structural changes, preliminary estimates suggest that both globalisation, proxied by measures of openness, import penetration and export intensity at the sectoral level, and digitalisation, proxied by ICT capital intensity at the sectoral level, are associated with higher wage divergence and tend to strengthen the link between productivity and wage dispersion within sectors and countries over time.

5. Finally, the report provides some preliminary analysis of the role of policy on the link between wage inequality and productivity dispersion focusing on minimum wage, employment protection legislation, trade union density, and coordination in wage setting. While the results are preliminary and only suggestive, as they capture conditional correlations rather than causal effect of policies,

they point to a positive link between higher minimum wages, unionisation, EPL and reduced wage inequality, and, in the case of the minimum wage, to a strengthening of the link between productivity and wages dispersion over time.

The results presented in the report are preliminary and will be extended in several ways in the next few months.

First, few additional countries might be able to provide data in the framework of the MultiProd project.[35]

Second, we aim at improving our measures of structural factors, by using different measures for both globalisation and digitalisation. For instance, we plan to focus on the impact of import penetration from China as well as include other measures of digitalisation that can help us identify sectors where winner-takes-all dynamics are more likely to arise, versus sectors where technological progress has translated into increased automation of production. We also want to investigate further the hypothesis that attributes increased divergence across both businesses and workers to rising market concentration, which is possible thanks to new information on sector concentration collected within the MultiProd project.

Third, we will extend the set of policies analysed, with a particular focus on policies related to product market regulation (in particular barriers to entry and barriers to trade and investment), possibly focusing on those service sectors where more detailed information on regulation is available. Another interesting avenue for future research would involve looking at policies that affect more directly the top of the productivity distribution, such as the tax treatment of stock options, or deferred compensation.

Finally, we recognise that a full account of the link between wage inequality and productivity divergence would ideally rely on linked employer-employee data. Unfortunately, this is a goal that might not be achievable in the very short term but we hope that future waves of the MultiProd project will be able to access these data, at least for the set of countries in which they are available. A wider availability of matched employer-employee data across countries would allow us to provide more detailed answers to these very policy relevant questions.

[35]For example, data for Indonesia and Portugal were received few weeks ago and will be included in the database in the coming weeks. Other countries such as the UK and Spain are also actively participating in the project and we hope to include them in the analysis in the near future.

References

Acemoglu, D. (1998), "Why Do New Technologies Complement Skills? Directed Technical Change and Wage Inequality", *The Quarterly Journal of Economics*, Vol. 113, No. 4, pp. 1055–1089.

Ackerberg, D., K. Caves, and G. Frazer (2015), "Identification Properties of Recent Production Function Estimators", *Econometrica*, Vol. 83, No. 6, pp. 2411–2451, DOI: https://doi.org/10.3982/ECTA13408.

Ackerberg, D., K. Caves, and G. Frazer (2006), "Structural Identification of Production Functions", *MPRA Paper* No. 38349, University Library of Munich, Germany.

Aghion, P., R. Blundell, R. Griffith, P. Howitt, and S. Prantl (2009), "The Effects of Entry on Incumbent Innovation and Productivity", *The Review of Economics and Statistics*, Vol. 91, No. 1, pp. 20–32.

Akerman, A., E. Helpman, O. Itskhoki, M.-A. Muendler, and S. Redding (2013), "Sources of Wage Inequality", *American Economic Review*, Vol. 103, No. 3, pp. 214–19.

Andrews, D., C. Criscuolo, and P. N. Gal (2016), "The Best versus the Rest: The Global Productivity Slowdown, Divergence across Firms and the Role of Public Policy", *OECD Productivity Working Papers* No. 5, OECD Publishing, Paris, DOI: https://doi.org/http://dx.doi.org/10.1787/63629cc9-en.

Autor, D. H. and D. Acemoglu (2011), "Skills, Tasks and Technologies: Implications for Employment and Earnings", in: *Handbook of Labor Economics*, ed. by O. Ashenfelter and D. Card, vol. 4B, Elsevier, Amsterdam, pp. 1043–1171.

Autor, D. H., D. Dorn, and G. H. Hanson (2013), "The China Syndrome: Local Labor Market Effects of Import Competition in the United States", *American Economic Review*, Vol. 103, No. 6, pp. 2121–68, DOI: https://doi.org/10.1257/aer.103.6.2121.

Autor, D. H., D. Dorn, L. F. Katz, C. Patterson, and J. V. Reenen (2017), "Concentrating on the Fall of the Labor Share", *NBER Working Paper* No. 23108, National Bureau of Economic Research.

Autor, D. H., F. Levy, and R. J. Murnane (2003), "The Skill Content of Recent Technological Change: An Empirical Exploration", *The Quarterly Journal of Economics*, Vol. 118, No. 4, pp. 1279–1333.

Bagger, J., K. L. Sørensen, and R. Vejlin (2013), "Wage sorting trends", *Economics Letters*, Vol. 118, No. 1, pp. 63–67, DOI: https://doi.org/10.1016/j.econlet.2012.09.

Bartelsman, E., J. Haltiwanger, and S. Scarpetta (2009), "Measuring and Analyzing Cross-country Differences in Firm Dynamics", in: *Producer Dynamics: New Evidence from Micro Data*, University of Chicago Press, pp. 15–76.

Bartelsman, E., S. Scarpetta, and F. Schivardi (2005), "Comparative Analysis of Firm Demographics and Survival: Evidence from Micro-level Sources in OECD Countries", *Industrial and Corporate Change*, Vol. 14, No. 3, pp. 365–391.

Barth, E., A. Bryson, J. C. Davis, and R. Freeman (2014), "It's Where You Work: Increases in Earnings Dispersion across Establishments and Individuals in the U.S." *NBER Working Paper* No. 20447, National Bureau of Economic Research.

Baumgarten, D. (2013), "Exporters and the Rise in Wage Inequality: Evidence from German Linked Employer-Employee Data", *Journal of International Economics*, Vol. 90, No. 1, pp. 201–217.

Baumgarten, D., G. Felbermayr, and S. Lehwald (2016), "Dissecting Between-Plant and Within-Plant Wage Dispersion – Evidence from Germany", *Ifo Working Paper Series* No. 216, Ifo Institute – Leibniz Institute for Economic Research at the University of Munich.

Berlingieri, G., P. Blanchenay, S. Calligaris, and C. Criscuolo (2017), "The MultiProd Project: a Comprehensive Overview", *OECD Science, Technology and Industry Working Papers* No. 2017/04, OECD Publishing, Paris.

Bloom, N., M. Draca, and J. Van Reenen (2016), "Trade Induced Technical Change? The Impact of Chinese Imports on Innovation, IT and Productivity", *The Review of Economic Studies*, Vol. 83, No. 1, pp. 87–117, DOI: https://doi.org/10.1093/restud/rdv039.

Calligaris, S., M. D. Gatto, F. Hassan, G. Ottaviano, and F. Schivardi (2016), "Italy's Productivity Conundrum. A Study on Resource Misallocation in Italy", *European Economy - Discussion Papers* No. 030, European Commission.

Card, D., A. R. Cardoso, J. Heining, and P. Kline (2016a), "Firms and Labor Market Inequality: Evidence and Some Theory", *NBER Working Paper* No. 22850, National Bureau of Economic Research.

Card, D., A. R. Cardoso, and P. Kline (2016b), "Bargaining, Sorting, and the Gender Wage Gap: Quantifying the Impact of Firms on the Relative Pay of Women", *The Quarterly Journal of Economics*, Vol. 131, No. 2, pp. 633–686.

Card, D., F. Devicienti, and A. Maida (2014), "Rent-Sharing, Holdup, and Wages: Evidence from Matched Panel Data", *The Review of Economic Studies*, Vol. 81, No. 1, pp. 84–111.

Card, D. and J. E. DiNardo (2002), "Skill-Biased Technological Change and Rising Wage Inequality: Some Problems and Puzzles", *Journal of Labor Economics*, Vol. 20, No. 4, pp. 733–783, DOI: https://doi.org/10.1086/342055.

Card, D., J. Heining, and P. Kline (2013), "Workplace Heterogeneity and the Rise of West German Wage Inequality", *The Quarterly Journal of Economics*, Vol. 128, No. 3, pp. 967–1015, DOI: https://doi.org/10.1093/qje/qjt006.

Card, D., T. Lemieux, and W. C. Riddell (2004), "Unions and wage inequality", *Journal of Labor Research*, Vol. 25, No. 4, pp. 519–559, DOI: https://doi.org/10.1007/s12122-004-1011-z.

Card, D. and S. D. L. Rica (2006), "Firm-Level Contracting and the Structure of Wages in Spain", *ILR Review*, Vol. 59, No. 4, pp. 573–592.

Carluccio, J., D. Fougère, and E. Gautier (2015), "Trade, Wages and Collective Bargaining: Evidence from France", *The Economic Journal*, Vol. 125, No. 584, pp. 803–837.

Caselli, F. (1999), "Technological Revolutions", *American Economic Review*, Vol. 89, No. 1, pp. 78–102, DOI: https://doi.org/10.1257/aer.89.1.78.

Christensen, B. and J. Bagger (2014), "Wage and Productivity Dispersion: The Roles of Rent Sharing, Labor Quality and Capital Intensity", *2014 Meeting Papers* No. 473, Society for Economic Dynamics.

Criscuolo, C., P. N. Gal, and C. Menon (2015), "DynEmp: A Routine for Distributed Microdata Analysis of Business Dynamics", *Stata Journal*, Vol. 15, No. 1, pp. 247–274.

Criscuolo, C., P. N. Gal, and C. Menon (2014), "The Dynamics of Employment Growth: New Evidence from 18 Countries", *OECD Science, Technology and Industry Policy Papers* No. 14, OECD Publishing, Paris, DOI: https://doi.org/http://dx.doi.org/10.1787/5jz417hj6hg6-en.

Dahl, C. M., D. le Maire, and J. R. Munch (2013), “Wage Dispersion and Decentralization of Wage Bargaining”, *Journal of Labor Economics*, Vol. 31, No. 3, pp. 501–533.

Davis, S. J. and J. Haltiwanger (1992), “Gross Job Creation, Gross Job Destruction, and Employment Reallocation”, *The Quarterly Journal of Economics*, Vol. 107, No. 3, pp. 819–863.

Decker, R. A., J. Haltiwanger, R. S. Jarmin, and J. Miranda (2017), “Changing Business Dynamism and Productivity: Shocks vs. Responsiveness”, *Mimeo*, Federal Reserve Board of Governors.

Decker, R. A., J. Haltiwanger, R. S. Jarmin, and J. Miranda (2016), “Where has all the Skewness Gone? The Decline in High-Growth (Young) Firms in the U.S.”, *European Economic Review*, Vol. 86, The Economics of Entrepreneurship, pp. 4–23, DOI: https://doi.org/10.1016/j.euroecorev.2015.12.013.

Dell’Aringa, C. and L. Pagani (2007), “Collective Bargaining and Wage Dispersion in Europe”, *British Journal of Industrial Relations*, Vol. 45, No. 1, pp. 29–54.

DiNardo, J. E., N. M. Fortin, and T. Lemieux (1996), “Labor Market Institutions and the Distribution of Wages, 1973–1992: A Semiparametric Approach”, *Econometrica*, Vol. 64, No. 5, pp. 1001–1044.

Dunne, T., L. Foster, J. Haltiwanger, and K. R. Troske (2004), “Wage and Productivity Dispersion in United States Manufacturing: The Role of Computer Investment”, *Journal of Labor Economics*, Vol. 22, No. 2, pp. 397–430.

Faggio, G., K. G. Salvanes, and J. Van Reenen (2010), “The Evolution of Inequality in Productivity and Wages: Panel Data Evidence”, *Industrial and Corporate Change*, Vol. 19, No. 6, pp. 1919–1951.

Fortin, N. M. and T. Lemieux (2015), “Changes in Wage Inequality in Canada: An Interprovincial Perspective”, *Canadian Journal of Economics*, Vol. 48, No. 2, pp. 682–713.

Furman, J. and P. Orszag (2015), “A Firm-Level Perspective on the Role of Rents in the Rise in Inequality”, Presentation at “A Just Society” Centennial Event in Honor of Joseph Stiglitz, Columbia University.

Gabaix, X. and A. Landier (2008), “Why has CEO Pay Increased So Much?”, *The Quarterly Journal of Economics*, Vol. 123, No. 1, pp. 49–100, DOI: https://doi.org/10.1162/qjec.2008.123.1.49.

Gatto, M. D., G. I. P. Ottaviano, and M. Pagnini (2008), “Openness To Trade And Industry Cost Dispersion: Evidence From A Panel Of Italian Firms”, *Journal of Regional Science*, Vol. 48, No. 1, pp. 97–129.

Goldschmidt, D. and J. F. Schmieder (2015), “The Rise of Domestic Outsourcing and the Evolution of the German Wage Structure”, *NBER Working Paper* No. 21366, National Bureau of Economic Research, DOI: https://doi.org/10.3386/w21366.

Gopinath, G., S. Kalemli-Ozcan, L. Karabarbounis, and C. Villegas-Sanchez (2015), “Capital Allocation and Productivity in South Europe”, *NBER Working Paper* No. 21453, National Bureau of Economic Research.

Gürtzgen, N. (2009), “Rent-sharing and Collective Bargaining Coverage: Evidence from Linked Employer-Employee Data”, *Scandinavian Journal of Economics*, Vol. 111, No. 2, pp. 323–349, DOI: https://doi.org/10.1111/j.1467-9442.2009.01566.x.

Håkanson, C., E. Lindqvist, and J. Vlachos (2015), “Firms and skills: the evolution of worker sorting”, *Working Paper Series* No. 9, IFAU - Institute for Evaluation of Labour Market and Education Policy.

Helpman, E., O. Itskhoki, M.-A. Muendler, and S. Redding (2017), “Trade and Inequality: From Theory to Estimation”, *Review of Economic Studies*, Vol. 84, No. 1, pp. 357–405.

Hsieh, C.-T. and P. J. Klenow (2009), “Misallocation and Manufacturing TFP in China and India”, *The Quarterly Journal of Economics*, Vol. 124, No. 4, pp. 1403–1448, DOI: https://doi.org/10.1162/qjec.2009.124.4.1403.

Ito, K. and S. Lechevalier (2009), “The Evolution of the Productivity Dispersion of Firms: A Reevaluation of its Determinants in the Case of Japan”, *Review of World Economics*, Vol. 145, No. 3, pp. 405–429.

Levinsohn, J. and A. Petrin (2003), “Estimating Production Functions Using Inputs to Control for Unobservables”, *The Review of Economic Studies*, Vol. 70, No. 2, pp. 317–341.

Machin, S. (2016), “Rising Wage Inequality, Real Wage Stagnation and Unions”, in: *Inequality: Causes and Consequences*, ed. by K. T. Solomon Polachek, Emerald Group Publishing Limited, pp. 329–354.

Manasse, P. and T. Manfredi (2014), “Wages, Productivity, and Employment in Italy: Tales from a Distorted Labour Market”, URL: http://voxeu.org/article/wages-productivity-and-employment-italy.

McKinnish, T. (2008), “Panel Data Models and Transitory Fluctuations in the Explanatory Variable”, in: *Modelling and Evaluating Treatment Effects in Econometrics*, ed. by T. Fomby, R. C. Hill, D. L. Millimet, J. A. Smith, and E. J. Vytlacil, pp. 335–358, DOI: https://doi.org/10.1016/S0731-9053(07)00011-4.

Melitz, M. J. (2003), “The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity”, *Econometrica*, Vol. 71, No. 6, pp. 1695–1725.

Mortensen, D. (2003), *Wage Dispersion: Why are Similar Workers Paid Differently?*, Zeuthen lecture book series, MIT Press, Cambridge, Massachussets.

Mueller, H. M., P. P. Ouimet, and E. Simintzi (2015), “Wage Inequality and Firm Growth”, *NBER Working Paper* No. 20876, National Bureau of Economic Research.

OECD (2016), *The Productivity-Inclusiveness Nexus*, OECD Publishing, Paris, DOI: https://doi.org/10.1787/9789264258303-en.

OECD (2015), *The Future of Productivity*, OECD Publishing, Paris, DOI: https://doi.org/10.1787/9789264248533-en.

Olley, G. S. and A. Pakes (1996), “The Dynamics of Productivity in the Telecommunications Equipment Industry”, *Econometrica*, Vol. 64, No. 6, pp. 1263–1297, DOI: https://doi.org/10.2307/2171831.

Piketty, T. (2014), *Capital in the 21st Century*, Harvard University Press, Cambridge, Massachussets.

Skans, O. N., P.-A. Edin, and B. Holmlund (2009), “Wage Dispersion Between and Within Plants: Sweden 1985-2000”, in: *The Structure of Wages: An International Comparison*, NBER Chapters, National Bureau of Economic Research, pp. 217–260.

Song, J., D. J. Price, F. Guvenen, N. Bloom, and T. von Wachter (2015), “Firming Up Inequality”, *NBER Working Paper* No. 21199, National Bureau of Economic Research, DOI: https://doi.org/10.3386/w21199.

Syverson, C. (2011), “What Determines Productivity?”, *Journal of Economic Literature*, Vol. 49, No. 2, pp. 326–365.

Syverson, C. (2004), “Product Substitutability and Productivity Dispersion”, *Review of Economics and Statistics*, Vol. 86, No. 2, pp. 534–550.

Timmer, M. P., E. Dietzenbacher, B. Los, R. Stehrer, and G. J. Vries (2015), " An Illustrated User Guide to the World Input-Output Database: the Case of the Global Automotive Production", *Review of International Economics*, Vol. 23, No. 3, pp. 575–605.

Van Biesebroeck, J. (2008), "Aggregating and Decomposing Productivity", *Review of Business and Economics*, Vol. 53, No. 2, pp. 122–146.

Wooldridge, J. M. (2009), "On Estimating Firm-Level Production Functions Using Proxy Variables to Control for Unobservables", *Economics Letters*, Vol. 104, No. 3, pp. 112–114.

APPENDIX

A. ADDITIONAL RESULTS

A.1 Documenting the dispersion increase

Results of regressing wage and productivity dispersion on time dummies, as given in Equation (7) and Equation (8), are given in Table A.1 and Table A.2, respectively.

Table A.1: Regressing wage dispersion on year dummies show an increase of wage dispersion over time, using the specification given in Equation (7).

	(1) LogW_pd90_10	(2) LogW_pd90_10
2002.year	-0.008	
2003.year	0.018**	
2004.year	0.019*	
2005.year	0.007	
2006.year	0.025***	
2007.year	0.041***	
2008.year	0.071***	
2009.year	0.087***	
2010.year	0.093***	
2011.year	0.103***	
2012.year	0.116***	
year		0.012***
Observations	3110	3110
Adj. R-Square	0.987	0.987
Country-sector FE	YES	YES
Nb Sectors	22	22
Nb Countries	14	14

Errors are clustered at the country-sector level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

For robustness, we also regress wage productivity dispersion on a time trend, with country-sector fixed effects, according to the following model:

$$\left(\log \frac{P_{90}}{P_{10}}\right)_{cjt} = \alpha + \beta year + z_{cj} + \varepsilon_{cjt} \tag{A.1}$$

The results are given in column 2 of Table A.1 for wage dispersion, and in Table A.3 for productivity dispersion.

Table A.2: Regressing productivity dispersion on year dummies show an increase of productivity dispersion over time, using the specification given in Equation (8).

	(1) LogLP_VA_pd90_10	(2) LogMFP_W_pd90_10	(3) LogMFP_SW_pd90_10
2002.year	0.021***	0.014*	0.008
2003.year	0.034***	0.029***	0.009
2004.year	0.063***	0.054***	0.027***
2005.year	0.040***	0.021	0.041***
2006.year	0.076***	0.057**	0.057***
2007.year	0.071***	0.066**	0.064***
2008.year	0.085***	0.075***	0.077***
2009.year	0.096***	0.085***	0.068***
2010.year	0.114***	0.092***	0.079***
2011.year	0.116***	0.098***	0.097***
2012.year	0.128***	0.136***	0.114***
Observations	3122	2997	3088
Adj. R-Square	0.987	0.997	0.962
Country-sector FE	YES	YES	YES
Nb Sectors	22	22	22
Nb Countries	14	14	14

Errors are clustered at the country-sector level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.3: Regressing productivity dispersion on a time trend shows an increase of productivity dispersion over time, according to Equation (A.1).

	(1) LogLP_VA_pd90_10	(2) LogMFP_W_pd90_10	(3) LogMFP_SW_pd90_10
year	0.011***	0.011***	0.010***
Observations	3122	2997	3088
Adj. R-Square	0.987	0.997	0.962
Country-sector FE	YES	YES	YES
Nb Sectors	22	22	22
Nb Countries	14	14	14

Errors are clustered at the country-sector level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

A.2 Correlation between productivity and wages

In order to better explore the link between productivity and wages, the MultiProd dataset has collected correlations between productivity and wages at the firm level. We can therefore investigate how the correlation has evolved over time by running the following regressions:

$$\text{Corr}(W,P)_{cjt} = \alpha + \beta_t y_t + z_{cj} + \varepsilon_{cjt} \tag{A.2}$$

where $\text{Corr}(W,P)$ is the between-firm correlation between wage and productivity.

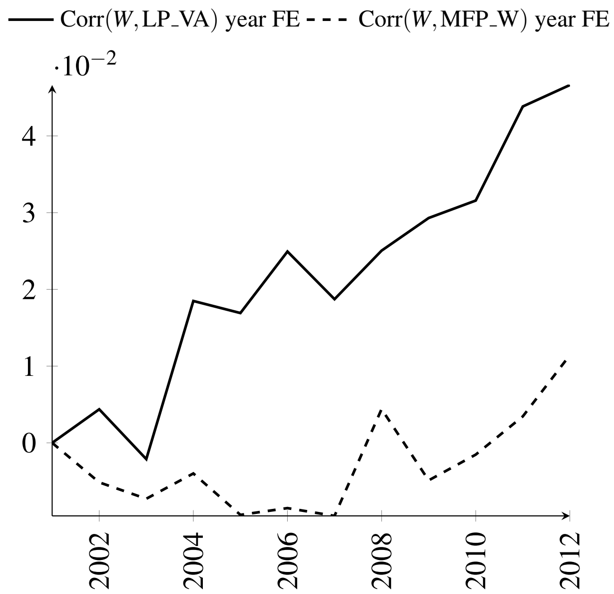
The results are reported in Table A.4 and plotted in Figure A.11. The figure shows that the correlation between wages and labour productivity has increased substantially over time, while year fixed effects on the correlation between wage and MFP have evolved in a non-linear way (many of the coefficients in column (2) of Table A.4 cannot be ruled out as distinct from zero). The pattern is interesting and it deserves further investigation. At this stage note that an increased correlation between the level of wages and productivity is not necessary for the dispersions of wages and productivity to be correlated. In fact it is well possible for the correlation to remain constant over time and, at the same time, for the dispersions to evolve hand-in-hand.

Table A.4: Regressing the correlation between wage and productivity on year dummies, using the specification given in Equation (A.2).

	(1) corr_W_LP_VA	(2) corr_W_MFP_W
2002.year	0.004	-0.005
2003.year	-0.002	-0.007**
2004.year	0.018***	-0.004
2005.year	0.017***	-0.009*
2006.year	0.025***	-0.009
2007.year	0.019*	-0.010
2008.year	0.025***	0.004
2009.year	0.029**	-0.005
2010.year	0.032***	-0.002
2011.year	0.044***	0.003
2012.year	0.047***	0.011
Observations	3160	3069
Adj. R-Square	0.920	0.969
Country-sector FE	YES	YES
Nb Sectors	22	22
Nb Countries	14	14

Errors are clustered at the country-sector level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure A.11: Wage-productivity correlation over time



Note: Plotting the year dummy estimates β_t on the firm-level correlation between wages and productivity, controlling for country-sector fixed effects. Year dummy estimates are reported in Table A.4.

A.3 Sectoral decomposition of wage variance

After establishing that wage dispersion has gone up across the whole economy and within each country-sector pair, we now turn to show that wage dispersion has indeed occurred mostly *within* narrowly defined sectors. Thanks to the MultiProd data, we can show that wage dispersion is not driven by differences in average wages across sectors but rather by differences in wages offered by firms within the same sectors. That is, even controlling for type of activity, there remains important heterogeneity in wages across firms. This analysis corroborates what was shown in the previous section and confirms that the within country-sector pairs variation captures most of the variation over time.

We decompose the total wage variance $\operatorname{Var} W_t$ into two components: a within-sector component, $\operatorname{Var}^W W_t$, and a cross-sector component, $\operatorname{Var}^X W_t$. The within-sector component of wage variance captures how much a firm's average wage differs from its sector (labour-weighted) average; the cross-sector component captures instead how much sectoral average wages vary from each other. More precisely, we use the following decomposition:

$$\operatorname{Var} W_t = \underbrace{\sum_j \frac{L_{jt}}{L_t} \sum_{i \in j} \frac{L_{it}}{L_{jt}} \left(W_{it} - \overline{W}_{jt}\right)^2}_{\operatorname{Var}^W W_t} + \underbrace{\sum_j \frac{L_{jt}}{L_t} \left(\overline{W}_{jt} - \overline{W}_t\right)^2}_{\operatorname{Var}^X W_t} \tag{A.3}$$

where i indexes firms and j denotes 2-digit sectors. This decomposition enables us to compute, in each period, the share of total cross-sectional wage variance $\operatorname{Var} W_t$ that comes from within-sector wage variance $\operatorname{Var}^W W_t$ and the share coming from the sectoral composition of the economy.

Table A.5: Share of within-sector wage variance

	% Wage dispersion	
	Manufacturing	Services
Australia (2012)	87	75
Austria (2012)	76	84
Belgium (2011)	62	73
Chile (2012)	69	86
Denmark (2012)	85	73
Finland (2012)	65	74
France (2012)	74	77
Hungary (2012)	69	84
Italy (2012)	80	83
Japan (2011)	79	80
Netherlands (2012)	71	96
Norway (2012)	87	82
Sweden (2012)	77	79

Note: Share of within-sector variance in total macro-sector wage variance. Firms and sectors weighted by the number of employees.

The first result of this cross-sectional decomposition is that within-sector dispersion accounts for the majority of wage dispersion in all countries and years. We perform the exercise decomposing the total wage variance of manufacturing and services, separately. Table A.5 reports the share of within-sector (defined at A38 level) wage variance in, respectively, manufacturing and services wage variance, in either 2011 or 2012 for the countries where data at the two-digit level are available. In our sample, within-sector dispersion accounts for at least 65% of wage dispersion in manufacturing, and at least 72% in services.

This indicates that wage variance is mainly due to the fact that firms within the same two-digit sector have very different average wages, rather than a reflection of the fact that firms in certain sectors (e.g. I.T. or telecommunications) offer average wages that are very different from those in the rest of the economy. The decomposition also allows us to identify which sectors contribute the most to the within-sector wage variance ($\text{Var}^W W_t$); in Tables A.6 and A.7 report for each country the top three contributors to $\text{Var}^W W_t$, for manufacturing and services respectively. The tables show that across countries some sectors, such as wholesale and retail trade, legal and accounting in services, and food, beverages and tobacco in manufacturing, regularly appear amongst the sectors characterised by the highest wage dispersion. This result suggests that the distribution of firms within these sectors share some features, such as the range or spread of the distribution, that might affect the distribution of wages.

Finally, the sectoral decomposition of wage variance also allows us to examine how the share of within-sector wage variance evolved over time. In Figure A.12, we plot the cross-country labour-weighted averages of the within-sector component over time. Our data indicate two very different dynamics in manufacturing vis-à-vis non-financial market services. In non-financial market services the evolution of wage dispersion is increasingly driven by a wage divergence within 2-digit sectors. On the

Table A.6: Top three sectors in the share of within-sector wage variance for Manufacturing

	Manufacturing	
	Sector	% Var. share
AUS (2012)	Basic metals and fabricated metal products, except	24
	Food products, beverages and tobacco [CA]	16
	Wood and paper products, and printing [CC]	13
AUT (2012)	Furniture; other manufacturing; repair and install	17
	Food products, beverages and tobacco [CA]	15
	Basic metals and fabricated metal products, except	14
BEL (2011)	Food products, beverages and tobacco [CA]	31
	Chemicals and chemical products [CE]	27
	Rubber and plastics products, and other non-metall	12
CHL (2012)	Chemicals and chemical products [CE]	17
	Food products, beverages and tobacco [CA]	13
	Coke and refined petroleum products [CD]	12
DNK (2012)	Food products, beverages and tobacco [CA]	29
	Machinery and equipment n.e.c. [CK]	23
	Furniture; other manufacturing; repair and install	11
FIN (2012)	Computer, electronic and optical products [CI]	26
	Wood and paper products, and printing [CC]	19
	Machinery and equipment n.e.c. [CK]	14
FRA (2012)	Food products, beverages and tobacco [CA]	18
	Transport equipment [CL]	11
	Computer, electronic and optical products [CI]	10
HUN (2012)	Basic metals and fabricated metal products, except	18
	Transport equipment [CL]	17
	Food products, beverages and tobacco [CA]	13
ITA (2012)	Machinery and equipment n.e.c. [CK]	18
	Basic metals and fabricated metal products, except	14
	Rubber and plastics products, and other non-metall	10
JPN (2011)	Transport equipment [CL]	20
	Food products, beverages and tobacco [CA]	16
	Chemicals and chemical products [CE]	14
NLD (2012)	Food products, beverages and tobacco [CA]	23
	Chemicals and chemical products [CE]	21
	Machinery and equipment n.e.c. [CK]	11
NOR (2012)	Furniture; other manufacturing; repair and install	36
	Food products, beverages and tobacco [CA]	14
	Machinery and equipment n.e.c. [CK]	12
NZL (2011)	Furniture; other manufacturing; repair and install	38
	Food products, beverages and tobacco [CA]	25
	Basic metals and fabricated metal products, except	11
SWE (2012)	Machinery and equipment n.e.c. [CK]	14
	Furniture; other manufacturing; repair and install	14
	Basic metals and fabricated metal products, except	14

Note: For each country, top three sectors that contribute the most to within-sector wage variance in manufacturing. The last columnn reports the share of within-sector variance that occurs in each sector.

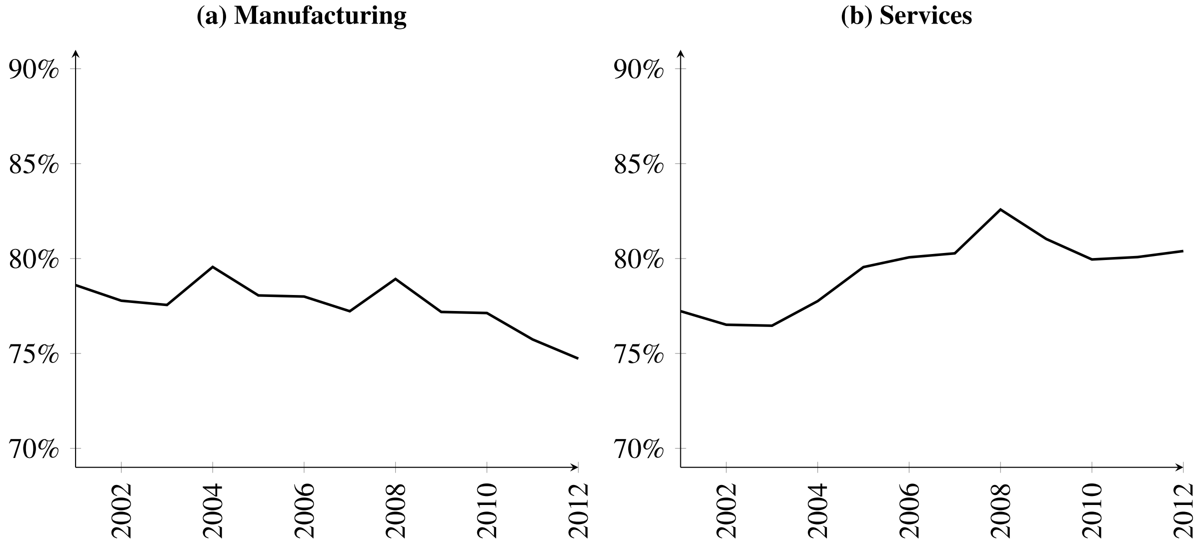
Table A.7: Top three sectors in the share of within-sector wage variance for Services

	Services	
	Sector.	% Var. share
AUS (2012)	Wholesale and retail trade, repair of motor vehicl	38
	Administrative and support service activities [N]	26
	Legal and accounting activities, etc [MA]	13
AUT (2012)	Wholesale and retail trade, repair of motor vehicl	33
	Legal and accounting activities, etc [MA]	22
	Transportation and storage [H]	12
BEL (2011)	Wholesale and retail trade, repair of motor vehicl	45
	Transportation and storage [H]	18
	Legal and accounting activities, etc [MA]	14
CHL (2012)	Wholesale and retail trade, repair of motor vehicl	30
	Advertising and market research; other professiona	22
	Transportation and storage [H]	10
DNK (2012)	Wholesale and retail trade, repair of motor vehicl	41
	Transportation and storage [H]	17
	Legal and accounting activities, etc [MA]	12
FIN (2012)	Wholesale and retail trade, repair of motor vehicl	36
	Legal and accounting activities, etc [MA]	18
	Transportation and storage [H]	17
FRA (2012)	Legal and accounting activities, etc [MA]	34
	Wholesale and retail trade, repair of motor vehicl	25
	Administrative and support service activities [N]	11
HUN (2012)	Wholesale and retail trade, repair of motor vehicl	29
	IT and other information services [JC]	16
	Legal and accounting activities, etc [MA]	16
ITA (2012)	Wholesale and retail trade, repair of motor vehicl	35
	IT and other information services [JC]	14
	Transportation and storage [H]	13
JPN (2011)	Wholesale and retail trade, repair of motor vehicl	37
	Legal and accounting activities, etc [MA]	36
	Administrative and support service activities [N]	9
NLD (2012)	Administrative and support service activities [N]	55
	Wholesale and retail trade, repair of motor vehicl	23
	Transportation and storage [H]	8
NOR (2012)	Wholesale and retail trade, repair of motor vehicl	30
	Legal and accounting activities, etc [MA]	17
	Transportation and storage [H]	13
NZL (2011)	Wholesale and retail trade, repair of motor vehicl	39
	Legal and accounting activities, etc [MA]	20
	Administrative and support service activities [N]	12
SWE (2012)	Wholesale and retail trade, repair of motor vehicl	29
	Legal and accounting activities, etc [MA]	24
	IT and other information services [JC]	10

Note: For each country, top three sectors that contribute the most to within-sector wage variance in services. The last columnn reports the share of within-sector variance that occurs in each sector.

other hand, in manufacturing we observe an opposite trend: although still relatively small, the role of the sectoral composition has been increasing over time and explains, as of 2012, one quarter of the observed wage inequality (up from 21% in 2001).

Figure A.12: Share of within-sector wage dispersion



Note: Share of within-sector dispersion in overall macro-sector wage dispersion. Average across countries and sectors, weighted by employment. Countries: AUS, AUT, BEL, CHL, DNK, FIN, FRA, HUN, ITA, JPN, NLD, NOR, NZL, SWE.

A.4 Sectoral decomposition of productivity variance

To better understand the drivers of the observed productivity dispersion, it is possible to decompose the total variance of productivity, $\mathrm{Var}\,P_t$, into two components: a within-sector component $\mathrm{Var}^W P_t$ and a cross-sectoral component, $\mathrm{Var}^X P_t$. The within-sector component captures how much a firm's individual productivity differs from the sector (weighted) average. The cross-sectoral component captures instead how much sectors differ from each other in terms of average productivity. We then get the following identity:

$$\mathrm{Var}\,P_t = \mathrm{Var}^W P_t + \mathrm{Var}^X P_t \tag{A.4}$$

where, the within-sector variance $\mathrm{Var}^W P_t$ is the average over all sectors j of the square deviation of firms' productivity P_{it} from their sector's weighted average productivity $\overline{P}_{jt}$; focusing, for simplicity, on labour productivity, this can be written as :

$$\mathrm{Var}^W P_t \equiv \frac{1}{L_t}\sum_j \sum_{i\in j} L_{it}\left(LP_{it} - \overline{LP}_{jt}\right)^2 = \sum_j \frac{L_{jt}}{L_t}\sum_{i\in j}\frac{L_{it}}{L_{jt}}\left(LP_{it} - \overline{LP}_{jt}\right)^2 = \sum_j \frac{L_{jt}}{L_t}\delta_{jt}^2 \tag{A.5}$$

and the cross-sectoral component $\mathrm{Var}^X P_t$ is the average of the squared deviation of sector j's average labour productivity $\overline{LP}_{jt}$ from the economy-wide productivity $\overline{LP}_t$:

$$\mathrm{Var}^X P_t \equiv \sum_j \frac{L_{jt}}{L_t}\left(\overline{LP}_{jt} - \overline{LP}_t\right)^2 \tag{A.6}$$

with $\frac{L_{jt}}{L_t}$ denoting the labour share of sector j at time t, and $\delta_{jt}^2 \equiv \sum_{i \in j} \frac{L_{it}}{L_{jt}} \left(LP_{it} - \overline{LP}_{jt}\right)^2$ the labour-weighted variance of firm-level labour productivity in sector j.

The same sectoral decomposition can be done for the variance of MFP, although the choice of weights is less trivial as discussed in more detail in Appendix A.4.1.

This decomposition can help understand how much of the dispersion in productivity comes from microeconomic dispersion within narrowly defined sectors, and how much comes from differences in productivity performance that affect whole sectors, due for example to sector-specific technological factors. This is achieved by looking at the share of aggregate dispersion accounted for by within-sector variance, which reflects the importance of factors that are firm specific, and different for firms within the same sector. The decomposition suggested here is a cross-sectional decomposition of productivity dispersion in a given period t.

Table A.8: Share of within-sector variance of log-labour productivity

	% Log LP dispersion	
	Manuf.	Services
Australia (2012)	97	89
Austria (2012)	83	88
Belgium (2011)	79	66
Chile (2012)	94	90
Denmark (2012)	84	73
Finland (2012)	66	69
France (2012)	70	72
Hungary (2012)	76	95
Italy (2012)	84	82
Japan (2011)	82	80
Netherlands (2012)	77	90
Norway (2012)	88	80
Sweden (2012)	68	80

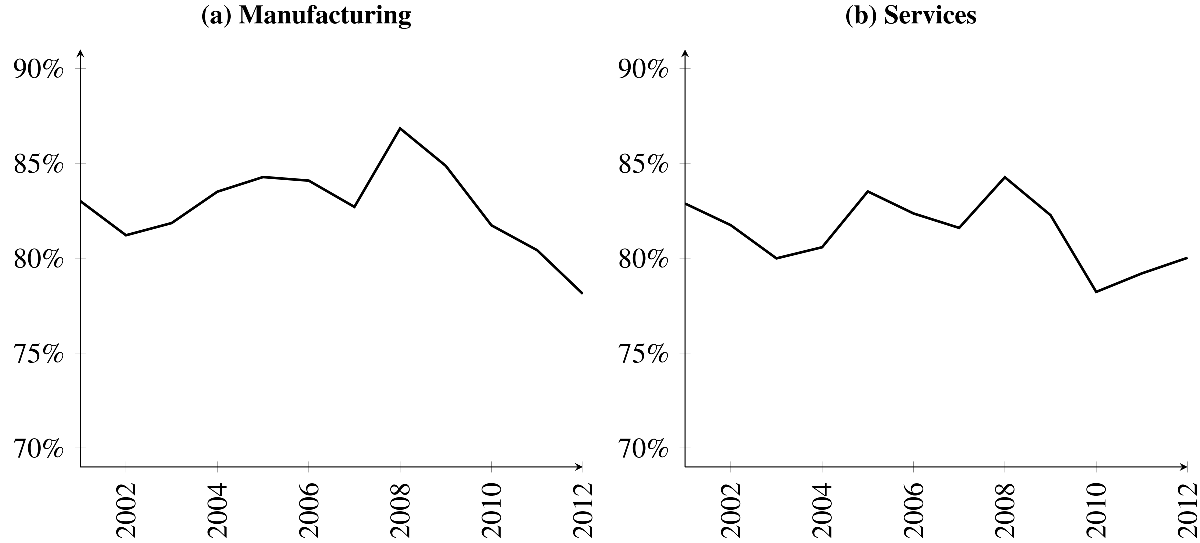
Note: Share of within-sector variance of log-labour productivity in total macro-sector productivity variance.

Table A.8 reports the results of the decomposition in the case of log-labour productivity.[36] The two columns report the share of total log-labour productivity dispersion accounted for by within-sector dispersion, for manufacturing and non-financial market services respectively. The results show that on average within-sector dispersion accounts for more than two thirds of the overall log-labour productivity dispersion observed across firms: there is still a large amount of heterogeneity in terms of log-labour productivity *between firms within the same two-digit sector*. In other words, a substantial part of productivity heterogeneity does not come from the type of activity that firms engage in, per se, but rather by more intrinsic differences between frontier firms and laggards, even within the same sector of activity in the same country. This suggests that productivity policies that aim at reducing economy-wide dispersion through structural adjustments in sectoral composition are unlikely to be effective in decreasing

[36] Very similar results, available from the authors upon request, are obtained in the case of labour productivity.

the gap between these two groups of firms on their own. These policies ought to be complemented by policies that work towards effective catching up of laggards to the national frontier firms that operate in the same sector. The decomposition also allows us to identify which sectors contribute the most to the within-sector log-productivity variance ($\text{Var}^W P_t$); in Tables A.9 and A.10 report for each country the top three contributors to $\text{Var}^W P_t$, for manufacturing and services respectively. The tables suggest that across countries some sectors, such as wholesale and retail trade, legal and accounting in services, and food, beverages and tobacco, or metal products in manufacturing, regularly appear amongst the sectors characterised by the highest productivity dispersion. This result suggests that the distribution of firms within these sectors share some features, such as the spread of the size or capital-intensity distributions, that might affect the distribution of productivity.[37]

Figure A.13: Share of within-sector log-labour productivity dispersion



Note: Share of within-sector dispersion in overall macro-sector Log-labour productivity dispersion. Average across countries and sectors, weighted by employment. Countries: AUS, AUT, BEL, CHL, DNK, FIN, FRA, HUN, ITA, JPN, NLD, NOR, NZL, SWE.

We now describe how the share of within-sector variance of labour productivity evolves over time, particularly in light of the Great Recession. The results, displayed in Figure A.13, suggest that within-sector variance of labour productivity remained the most important component of overall variance, well above 75%, but its importance declined in both manufacturing and services after 2008. In other words, this suggests that in the aftermath of the crisis a larger share of the productivity dispersion came from productivity differences *across* rather than within sectors. This might suggest that the aggregate shock of the Great Recession might have affected systematically more certain sectors, such as durables, relative to how systematically it has affected firms at the top and the bottom of the productivity distribution within sectors. Nonetheless, this impact still left a large part of productivity heterogeneity that cannot be explained by sectoral differences, suggesting that cross-sectoral analyses are likely to underestimate the amount of productivity divergence in the economy.

[37]Note that these are the same sectors that also appeared amongst those with the highest wage dispersion.

Table A.9: Top three sectors in the share of within-sector Log-LP_VA variance for Manufacturing

	Manufacturing	
	Sector	% Var. share
AUS (2012)	Food products, beverages and tobacco [CA]	33
	Basic metals and fabricated metal products, except	22
	Wood and paper products, and printing [CC]	8
AUT (2012)	Food products, beverages and tobacco [CA]	18
	Basic metals and fabricated metal products, except	16
	Wood and paper products, and printing [CC]	14
BEL (2011)	Food products, beverages and tobacco [CA]	44
	Chemicals and chemical products [CE]	13
	Rubber and plastics products, and other non-metall	10
CHL (2012)	Food products, beverages and tobacco [CA]	38
	Basic metals and fabricated metal products, except	14
	Wood and paper products, and printing [CC]	13
DNK (2012)	Food products, beverages and tobacco [CA]	31
	Furniture; other manufacturing; repair and install	18
	Machinery and equipment n.e.c. [CK]	13
FIN (2012)	Wood and paper products, and printing [CC]	28
	Machinery and equipment n.e.c. [CK]	14
	Basic metals and fabricated metal products, except	11
FRA (2012)	Food products, beverages and tobacco [CA]	25
	Basic metals and fabricated metal products, except	10
	Rubber and plastics products, and other non-metall	10
HUN (2012)	Furniture; other manufacturing; repair and install	16
	Food products, beverages and tobacco [CA]	15
	Wood and paper products, and printing [CC]	14
ITA (2012)	Basic metals and fabricated metal products, except	17
	Machinery and equipment n.e.c. [CK]	13
	Textiles, wearing apparel, leather and related pro	12
JPN (2011)	Food products, beverages and tobacco [CA]	25
	Machinery and equipment n.e.c. [CK]	13
	Basic metals and fabricated metal products, except	13
NLD (2012)	Food products, beverages and tobacco [CA]	25
	Chemicals and chemical products [CE]	16
	Machinery and equipment n.e.c. [CK]	12
NOR (2012)	Food products, beverages and tobacco [CA]	18
	Basic metals and fabricated metal products, except	15
	Furniture; other manufacturing; repair and install	14
SWE (2012)	Furniture; other manufacturing; repair and install	35
	Wood and paper products, and printing [CC]	13
	Machinery and equipment n.e.c. [CK]	12

Note: For each country, top three sectors that contribute the most to within-sector Log-LP_VA variance in manufacturing. The last column reports the share of within-sector variance that occurs in each sector.

Table A.10: Top three sectors in the share of within-sector Log-LP_VA variance for Services

	Services	
	Sector	% Var. share
AUS (2012)	Wholesale and retail trade, repair of motor vehicl	40
	Transportation and storage [H]	16
	Legal and accounting activities, etc [MA]	14
AUT (2012)	Wholesale and retail trade, repair of motor vehicl	41
	Transportation and storage [H]	11
	Legal and accounting activities, etc [MA]	10
BEL (2011)	Wholesale and retail trade, repair of motor vehicl	47
	Administrative and support service activities [N]	21
	Transportation and storage [H]	9
CHL (2012)	Wholesale and retail trade, repair of motor vehicl	54
	Advertising and market research; other professiona	13
	Transportation and storage [H]	9
DNK (2012)	Wholesale and retail trade, repair of motor vehicl	39
	Administrative and support service activities [N]	12
	Accommodation and food service activities [I]	12
FIN (2012)	Wholesale and retail trade, repair of motor vehicl	39
	Administrative and support service activities [N]	13
	REAL ESTATE ACTIVITIES [L]	10
FRA (2012)	Wholesale and retail trade, repair of motor vehicl	29
	Administrative and support service activities [N]	17
	Legal and accounting activities, etc [MA]	12
HUN (2012)	Wholesale and retail trade, repair of motor vehicl	35
	Administrative and support service activities [N]	14
	Legal and accounting activities, etc [MA]	13
ITA (2012)	Wholesale and retail trade, repair of motor vehicl	38
	Transportation and storage [H]	14
	Administrative and support service activities [N]	12
JPN (2011)	Legal and accounting activities, etc [MA]	39
	Wholesale and retail trade, repair of motor vehicl	25
	Administrative and support service activities [N]	15
NLD (2012)	Wholesale and retail trade, repair of motor vehicl	43
	Administrative and support service activities [N]	21
	Transportation and storage [H]	12
NOR (2012)	Wholesale and retail trade, repair of motor vehicl	35
	Administrative and support service activities [N]	13
	Legal and accounting activities, etc [MA]	13
SWE (2012)	Wholesale and retail trade, repair of motor vehicl	32
	Legal and accounting activities, etc [MA]	15
	REAL ESTATE ACTIVITIES [L]	11

Note: For each country, top three sectors that contribute the most to within-sector Log-LP_VA variance in services. The last columnn reports the share of within-sector variance that occurs in each sector.

A.4.1 Additional results on sectoral decomposition of MFP variance

The same sectoral decomposition of productivity done in Appendix A.4 for labour productivity can also be performed on the variance of MFP, yielding an equation similar to Equation (A.4):

$$\operatorname{Var} P_t' = \sum_j \omega_{jt} \sum_{i \in j} \frac{\omega_{it}}{\omega_{jt}} \left(P_{it}' - \overline{P_{jt}'} \right)^2 + \sum_j \omega_{jt} \left(\overline{P_{jt}'} - \overline{P_t'} \right)^2 \tag{A.7}$$

where $\overline{P_{jt}'} \equiv \sum_{i \in j} \omega_{it} P_{it}'$ and $\overline{P_t'} \equiv \sum_j \omega_{jt} \sum_{i \in j} \omega_{it} P_{it}'$ are, respectively, the weighted MFP average in sector j and in the whole economy. Again, the first term is the within-sector variance of MFP, while the second captures variance between sectors.

However, while Equation (A.4) gives the exact variance decomposition of labour productivity by using labour weights, the choice of the appropriate weights $\{\omega\}_i$ becomes less straightforward with MFP. Because of the multiple inputs, using labour weights would results in underweighting capital-intensive firms or sectors. In the literature it is common to use output weights (either GO or VA depending on how MFP is estimated) and for this decomposition we use VA weights for MFP.[38] The results are given in Table A.11. Moreover, as for Log-LP_VA variance, Tables A.12 and A.13 present the three sectors that contribute the most to within-sector Log-MFP_W variance, for manufacturing and services respectively.

Table A.11: Share of within-sector variance of productivity

	% Log MFP dispersion	
	Manuf.	Services
Australia (2012)	53	75
Austria (2012)	9	4
Belgium (2011)	57	82
Chile (2012)	62	47
Denmark (2012)	21	26
Finland (2012)	14	25
France (2012)	16	55
Hungary (2012)	61	92
Italy (2012)	62	45
Japan (2011)	27	8
Netherlands (2012)	50	52
Norway (2012)	69	38
Sweden (2012)	18	1

Note: Share of within-sector variance of MFP-Woodldrige in total macrosector productivity variance.

[38] The code also allows an actual decomposition, using the input weights methodology developed by Van Biesebroeck (2008).

Table A.12: Top three sectors in the share of within-sector Log-MFP_W variance for Manufacturing

	Manufacturing	
	Sector	% Var. share
AUS (2012)	Food products, beverages and tobacco [CA]	28
	Basic metals and fabricated metal products, except	28
	Machinery and equipment n.e.c. [CK]	16
AUT (2012)	Computer, electronic and optical products [CI]	21
	Furniture; other manufacturing; repair and install	17
	Electrical equipment [CJ]	15
BEL (2011)	Food products, beverages and tobacco [CA]	39
	Chemicals and chemical products [CE]	23
	Rubber and plastics products, and other non-metall	9
CHL (2012)	Basic metals and fabricated metal products, except	39
	Food products, beverages and tobacco [CA]	34
	Wood and paper products, and printing [CC]	9
DNK (2012)	Furniture; other manufacturing; repair and install	25
	Food products, beverages and tobacco [CA]	20
	Machinery and equipment n.e.c. [CK]	15
FIN (2012)	Wood and paper products, and printing [CC]	22
	Machinery and equipment n.e.c. [CK]	19
	Basic pharmaceutical products and pharmaceutical p	13
FRA (2012)	Food products, beverages and tobacco [CA]	29
	Computer, electronic and optical products [CI]	24
	Rubber and plastics products, and other non-metall	11
HUN (2012)	Machinery and equipment n.e.c. [CK]	24
	Food products, beverages and tobacco [CA]	16
	Transport equipment [CL]	13
ITA (2012)	Machinery and equipment n.e.c. [CK]	17
	Basic metals and fabricated metal products, except	12
	Food products, beverages and tobacco [CA]	12
JPN (2011)	Food products, beverages and tobacco [CA]	25
	Chemicals and chemical products [CE]	14
	Machinery and equipment n.e.c. [CK]	14
NLD (2012)	Chemicals and chemical products [CE]	35
	Food products, beverages and tobacco [CA]	24
	Basic metals and fabricated metal products, except	15
NOR (2012)	Machinery and equipment n.e.c. [CK]	22
	Basic metals and fabricated metal products, except	16
	Furniture; other manufacturing; repair and install	13
SWE (2012)	Computer, electronic and optical products [CI]	53
	Wood and paper products, and printing [CC]	12
	Basic metals and fabricated metal products, except	9

Note: For each country, top three sectors that contribute the most to within-sector Log-MFP_W variance in manufacturing. The last columnn reports the share of within-sector variance that occurs in each sector.

Table A.13: Top three sectors in the share of within-sector Log-MFP_W variance for Services

	Services	
	Sector	% Var. share
AUS (2012)	Wholesale and retail trade, repair of motor vehicl	56
	Transportation and storage [H]	16
	Legal and accounting activities, etc [MA]	11
AUT (2012)	REAL ESTATE ACTIVITIES [L]	36
	Transportation and storage [H]	25
	Wholesale and retail trade, repair of motor vehicl	19
BEL (2011)	Wholesale and retail trade, repair of motor vehicl	53
	Transportation and storage [H]	18
	Administrative and support service activities [N]	12
CHL (2012)	Wholesale and retail trade, repair of motor vehicl	62
	Transportation and storage [H]	14
	Advertising and market research; other professiona	9
DNK (2012)	Wholesale and retail trade, repair of motor vehicl	31
	Legal and accounting activities, etc [MA]	20
	Administrative and support service activities [N]	13
FIN (2012)	Wholesale and retail trade, repair of motor vehicl	35
	REAL ESTATE ACTIVITIES [L]	17
	Administrative and support service activities [N]	14
FRA (2012)	Wholesale and retail trade, repair of motor vehicl	29
	Transportation and storage [H]	14
	Legal and accounting activities, etc [MA]	13
HUN (2012)	Wholesale and retail trade, repair of motor vehicl	41
	Transportation and storage [H]	20
	Administrative and support service activities [N]	14
ITA (2012)	Wholesale and retail trade, repair of motor vehicl	30
	Transportation and storage [H]	19
	Administrative and support service activities [N]	15
JPN (2011)	Wholesale and retail trade, repair of motor vehicl	36
	Legal and accounting activities, etc [MA]	26
	Telecommunications [JB]	13
NLD (2012)	Wholesale and retail trade, repair of motor vehicl	73
	Transportation and storage [H]	14
	Legal and accounting activities, etc [MA]	5
NOR (2012)	Wholesale and retail trade, repair of motor vehicl	36
	Telecommunications [JB]	18
	Transportation and storage [H]	16
SWE (2012)	REAL ESTATE ACTIVITIES [L]	87
	IT and other information services [JC]	4
	Wholesale and retail trade, repair of motor vehicl	3

Note: For each country, top three sectors that contribute the most to within-sector Log-MFP_W variance in services. The last columnn reports the share of within-sector variance that occurs in each sector.

A.5 The link between wage and productivity dispersion: robustness

In this section we investigate the robustness of the link between wage and productivity dispersion.

Table A.14: Regressing wage dispersion on productivity dispersion (pooled regression)

	(1) log Wage (90-10)	(2) log Wage (90-10)	(3) log Wage (90-10)
log LP (90-10)	0.840***		
	(0.086)		
log MFP_W (90-10)		0.529***	
		(0.088)	
log MFP_SW (90-10)			0.586***
			(0.190)
N	3740	3624	3713
Adj. R-Square	0.730	0.358	0.420
Year FE	YES	YES	YES
Country-sector FE	NO	NO	NO
Nb Sectors	22	22	22
Nb Countries	14	14	14

Standardised beta coefficients; Errors are clustered at the country-sector level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Countries: AUS, AUT, BEL, CHL, DNK, FIN, FRA, HUN, ITA, JPN, NLD, NOR, NZL, SWE.

First, to confirm the robustness of the estimates of Equation (9), we perform two exercises. First, we estimate the following regression:

$$WD_{cjt} = \alpha + \beta \cdot PD_{cjt} \quad \left(+\gamma \cdot \text{High-Skilled}_{cjt}\right) + y_t + \varepsilon_{cjt} \tag{A.8}$$

The results, given in Table A.14, show that the pooled regression of Equation (A.8) obtains qualitatively the same results as the regression with country-sector fixed effects of Equation (9). Unsurprisingly, estimates for β are higher without the inclusion of these fixed effects; this shows that sectoral and country characteristics, which also affect productivity dispersion, are still important determinants of wage dispersion. That estimates for β remain positive and significant when these fixed effects are included shows however that an important "within" variation is not captured by time-invariant characteristics, and justifies our initial analysis.

Second, fixed-effects models might be affected by measurement error, as they might be contaminated by temporary fluctuations: the 'signal' of structural changes in productivity dispersion might be overwhelmed by the 'noise' of transitory changes, causing the variation left for identification to largely reflect transitory and idiosyncratic changes, rather than longer term changes (McKinnish, 2008). Therefore, to confirm the robustness of the estimates of Equation (9), we estimate the first-difference equation:

$$\Delta WD_{cjt} = \alpha + \beta \cdot \Delta PD_{cjt} \quad \left(+\gamma \cdot \Delta\text{High-Skilled}_{cjt}\right) + y_t + \varepsilon_{cjt} \tag{A.9}$$

where Δ in Equation (A.9) denotes long differences. Equation (A.9) estimates the link between changes in wage inequality and in productivity dispersion using long differences between 2005 and 2012, the period for which we can compute long differences for a significant number of countries.

Long difference estimates reported in Table A.15 similarly confirm that, for our two main measures of productivity LP and MFP_W, and whether controls for skills are included or not, an increase of the dispersion in labour productivity correlates with a significant increase in wage dispersion.

Table A.15: Regressing wage dispersion on productivity dispersion (2005-2012 change)

	(1) Δ log Wages (90-10)	(2) Δ log Wages (90-10)	(3) Δ log Wages (90-10)	(4) Δ log Wages (90-10)	(5) Δ log Wages (90-10)	(6) Δ log Wages (90-10)
Δ log LP (90-10)	0.348***			0.258**		
	(0.071)			(0.152)		
Δ log MFP_W (90-10)		0.435***			0.421***	
		(0.060)			(0.109)	
Δ log MFP_SW (90-10)			0.126			0.285***
			(0.096)			(0.090)
Δ % hrs by skilled workers				0.089	0.110	0.130*
				(0.539)	(0.433)	(0.494)
N	1710	1664	1689	774	754	770
Adj. R-Square	0.125	0.122	0.013	0.059	0.099	0.048
Nb Sectors	22	22	22	22	22	22
Nb Countries	13	13	13	9	9	9

Standardised beta coefficients; Robust standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
The number of observations reported is for all years, but the regression is run on long differences, with one observation per country-sector.
Countries: AUS, BEL, CHL, DNK, FIN, FRA, HUN, ITA, JPN, NLD, NOR, NZL, SWE.

A.6 The role of policies: additional results

Table A.16 show the results of the regression of wage dispersion on labour productivity dispersion, each of the considered policies and their interaction. Compared to the results for MFP in the main text, the pattern is more mixed. The most robust result is the direct negative impact that policies have on wage dispersion over time. The effect of the minimum wage on the link between wage and productivity dispersion still changes sign between the cross-sectional and the within country-sector estimates, but the effect appears to be insignificant. Similarly, the estimates of the interaction term between labour productivity and the other policies are smaller in magnitude and partially lose significance with respect to MFP. Some of the cross-sectional results are at odds with the previous ones for MFP. Much of this could be driven by unobservable characteristics that are not controlled for in the cross-section, but, still, the results clearly deserve further investigation. In particular, labour productivity is driven by the level of capital intensity of the firms, and the impact of the policy will depend on whether firms substitute capital with labour, or whether capital and labour are gross complement.[39]

[39] We cannot test these hypotheses with the data currently available in the MultiProd database. But we intend to collect information that might help shed further light on these results in the next wave of MultiProd.

Table A.16: Divergences and Policy (LP)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log LP (90-10)	0.597***	0.237***	0.553***	0.256***	0.419***	0.268***	0.349***	0.262***	0.421***	0.237***
	(0.049)	(0.072)	(0.047)	(0.075)	(0.059)	(0.041)	(0.083)	(0.044)	(0.070)	(0.045)
Real Min Wage (hour)	0.121***	-0.295***								
	(0.025)	(0.094)								
Log LP (90-10) × Real Min Wage (hour)	-0.071	0.041								
	(0.047)	(0.033)								
Relative Min Wage (wrt av)			0.047	-0.097**						
			(0.034)	(0.041)						
Log LP (90-10) × Relative Min Wage (wrt av)			-0.063	0.022						
			(0.046)	(0.022)						
EPL (indiv. and coll.)					0.014	-0.050*				
					(0.045)	(0.030)				
Log LP (90-10) × EPL (indiv. and coll.)					0.065*	-0.037				
					(0.039)	(0.033)				
Trade union density							0.063	-0.359***		
							(0.042)	(0.051)		
Log LP (90-10) × Trade union density							-0.131	-0.005		
							(0.083)	(0.026)		
Wage Setting									0.130***	-0.068***
									(0.032)	(0.014)
Log LP (90-10) × Wage Setting									-0.037	-0.029**
									(0.056)	(0.012)
N	1890	1889	1890	1889	3564	3563	3564	3563	3564	3563
Adj. R-Square	0.794	0.970	0.788	0.969	0.507	0.969	0.570	0.971	0.555	0.969
Year FE	YES		YES		YES		YES		YES	
Country-sector year FE		YES		YES		YES		YES		YES
Num. Countries	7	7	7	7	13	13	13	13	13	13

Clustered standard errors at the country-sector level in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The dependent variable is Log Wage (90-10), all regressors are standardised and the coefficients can be interpreted as the effect at the mean.

The largest set of countries include: AUS AUT BEL DNK FIN FRA HUN ITA JPN NLD NOR NZL SWE.

B. EVOLUTION OF MISALLOCATION OVER TIME

The MultiProd database also contains a set of measures related to the efficiency of the allocation of resources or their misallocation. In particular it contains various measures of static allocative efficiency, computed as covariances à la Olley and Pakes (1996) for both labour productivity and MFP, and various sets of weights. Moreover it contains estimates of misallocation for capital, labour, and the total economy following the methodology of Hsieh and Klenow (2009) and various modifications to it (e.g. drop the assumptions of constant return to scale, unique elasticity across sectors etc.). Investigating the determinants of the evolution of misallocation, its impact on wages and productivity, the role of policies etc. would certainly require a separate more detailed analysis, which is left for future research. Here we limit ourselves to show some interesting patterns over time, which can be taken as food for thought for the next steps of the analysis. More details on the methodology and the description of the variables contained in MultiProd can be found in Berlingieri et al. (2017).

As in the case of wages and productivity we investigate the patterns over time running the following regression:

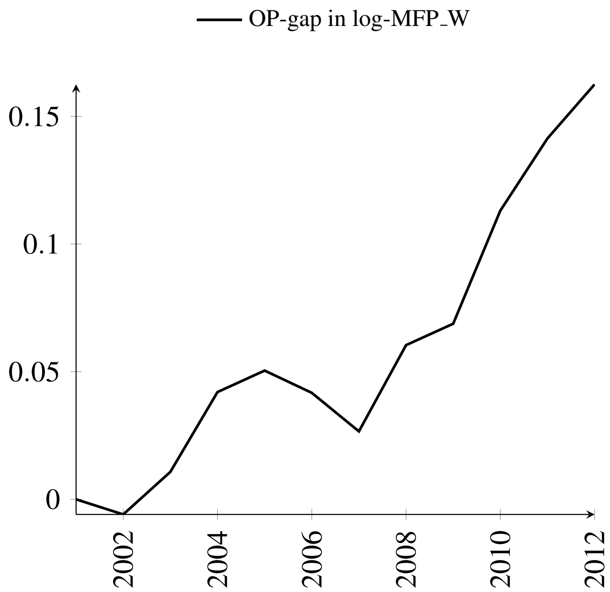
$$M_{cjt} = \alpha + \beta_t y_t + z_{cj} + \varepsilon_{cjt} \tag{B.10}$$

where M_{cjt} is a measure of misallocation.

Figures B.14, B.15, and B.16 together with Table B.17 show the results of the exercise for the OP gap computed on MFP and various measures of misallocation. A first interesting pattern is that both the OP gap and almost all measures of misallocation increase over time. Since an increase in the Olley and Pakes's (1996) covariance term is normally interpreted as an increase in the efficiency of the allocation of resources, we are left with a conflicting message that deserves further exploration. There are various theoretical and empirical reasons for why the two measures might differ, but given their widespread use and the importance of an efficient allocation of resources in guiding policy prescriptions, it would be key to understand exactly what is driving this pattern. A second result is that looking at the increase of misallocation over time in Figure B.15, it emerges that is is almost entirely driven by an increase in the misallocation of capital. The result is not new in the literature, for instance Gopinath et al. (2015) find a similar patter for southern European countries, but the MultiProd data allows us to expand the evidence to a much larger set of countries.

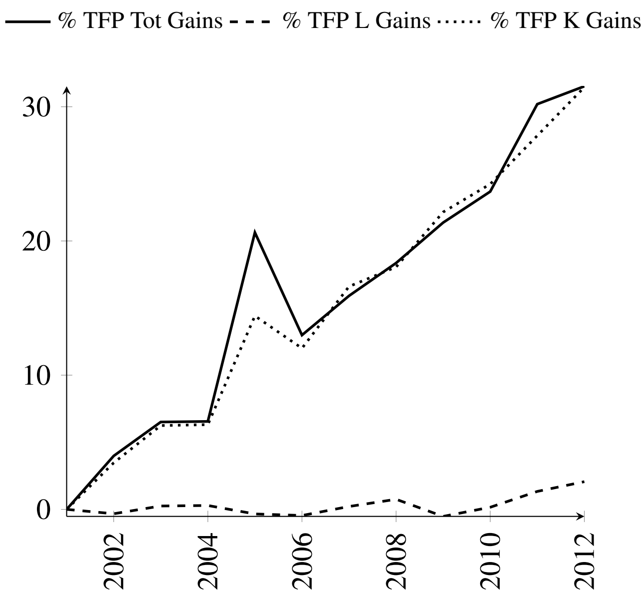
Results of regressing various misallocation measures on time dummies, similar to Equation (8), are given in Table B.17. For robustness, we also regress misallocation measures on a time trend, with country-sector fixed effects. The results are given in Table B.18

Figure B.14: Increase of OP-gap over time



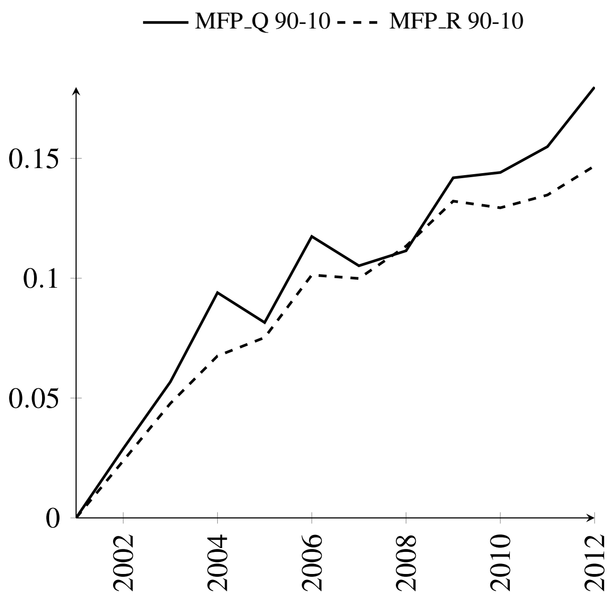
Note: Plotting the year dummy estimates β_t on misallocation measured as the Olley and Pakes (1996) gap, controlling for country-sector fixed effects. Year dummy estimates are reported in Table B.17.

Figure B.15: Increase in misallocation



Note: Plotting the year dummy estimates β_t of a regression of misallocation measures on year and country-sector fixed effects. Misallocation is measured as % TFP gains available by removing firm-level wedges, following Hsieh and Klenow (2009) methodology. Year dummy estimates are reported in Table B.17.

Figure B.16: Increase in 90-10 interquantile range of structurally estimated productivity



Note: Plotting the year dummy estimates β_t of a regression of firm-level MFP dispersion on year and country-sector fixed effects. MFP is structurally estimated following Hsieh and Klenow (2009) methodology.

Table B.17: Regressing misallocation measures on year dummies show an increase of inefficiencies over time.

	(1) LogLP_VA_w_L_opgap	(2) LogMFP_W_w_VA_opgap	(3) HK_gain_perc_1	(4) HK_gain_perc_1_L	(5) HK_gain_perc_1_K
2002.year	0.003	-0.006	3.983**	-0.326	3.470**
2003.year	0.018***	0.011	6.511**	0.251	6.246**
2004.year	0.033***	0.042*	6.552***	0.288	6.313***
2005.year	0.022**	0.050**	20.629**	-0.342	14.416*
2006.year	0.032**	0.042	12.984*	-0.457	12.004*
2007.year	0.045***	0.027	15.912**	0.214	16.609**
2008.year	0.044**	0.060***	18.356***	0.751	18.060**
2009.year	0.036**	0.069***	21.369**	-0.524	22.153**
2010.year	0.047***	0.113***	23.680***	0.156	24.237***
2011.year	0.041***	0.141***	30.196***	1.337	27.846***
2012.year	0.043***	0.163***	31.526***	2.063	31.457***
Observations	3159	2567	3180	3180	3180
Adj. R-Square	0.933	0.997	0.716	0.965	0.656
Country-sector FE	YES	YES	YES	YES	YES
Nb Sectors	22	22	22	22	22
Nb Countries	14	12	14	14	14

Errors are clustered at the country-sector level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table B.18: Regressing misallocation measures on a time trend shows an increase of inefficiencies over time.

	(1) LogLP_VA_w_L_opgap	(2) LogMFP_W_w_VA_opgap	(3) HK_gain_perc_1	(4) HK_gain_perc_1_L	(5) HK_gain_perc_1_K
year	0.004^{**}	0.015^{***}	2.681^{***}	0.140	2.753^{***}
Observations	3159	2567	3180	3180	3180
Adj. R-Square	0.932	0.997	0.717	0.964	0.657
Country-sector FE	YES	YES	YES	YES	YES
Nb Sectors	22	22	22	22	22
Nb Countries	14	12	14	14	14

Errors are clustered at the country-sector level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

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