ARTIGO **05** • **2023**

THE LINK BETWEEN PRODUCTIVITY AND WAGES: THE ROLE OF THE MINIMUM WAGE IN PORTUGAL

João Pedro de Oliveira Afonso[1] e Sílvia Fonte-Santa[23]

Abstract

An increase in the Portuguese minimum wage has been positively correlated with the relationship between productivity and wages on the 90-10 and 50-10 percentile differences, respectively. Applying a fixed effects regression, this paper shows that the minimum wage, measured through the relative minimum wage, had two reverse but complementary effects: it has led to a compression of the wage distribution through its wage biting effects and, simultaneously, led to strengthening of the correlation between wages and productivity dispersions, between-firms within each sector. The results found are being driven by the service sector of the economy.

Keywords: Public Policy, Minimum Wage, Wage Dispersion, Productivity Dispersion, Fixed Effects

JEL Classification: J38, L25

Gabinete de Planeamento, Estratégia, Avaliação e Relações Internacionais
Ministério das Finanças
Rua da Alfândega n.º 5A • 1100 – 016 Lisboa
www.gpeari.gov.pt

[1] Nova School of Business and Economics.
[2] Banco de Portugal (article prepared when performing duties at GPEARI).
[3] This article results from a master thesis developed during an internship at GPEARI. The authors thank the supervision of Susana Peralta – Nova SBE and Ana Fontoura Gouveia – Nova SBE. The opinions expressed are those of the authors and not necessarily of the institutions.This work used infrastructure and resources funded by Fundação para a Ciência e a Tecnologia (UID/ECO/00124/2013, UID/ECO/00124/2019 and Social Sciences DataLab, Project 22209), POR Lisboa (LISBOA-01-0145-FEDER-007722 and Social Sciences DataLab, Project 22209) and POR Norte (Social Sciences DataLab, Project 22209).

THE LINK BETWEEN PRODUCTIVITY AND WAGES: THE ROLE OF THE MINIMUM WAGE IN PORTUGAL

1. Introduction

Minimum wage policies have been an important vehicle for wage restructuring and reducing inequality. Although its effects on employment remain central, albeit uncertain, the impact on productivity remains an important avenue for further consideration.

The evolution of the Portuguese minimum wage over the past two decades serves as an intriguing subject for economic analysis. Between 2006 and 2019, there was a noteworthy increase in the nominal wage, from 385.9 to 600 euros, amounting to a real growth of 30%. However, this evolution was not characterized by a consistent upward trend, but rather it can be dissected into three distinct periods.

The first, from 2006 to 2011, when the real minimum wage experienced an average growth of 2.8%. Subsequently, there was a period of stagnation in the minimum wage from 2011 to 2014, during which it remained fixed at 485 euros. Thus, the real value of the minimum wage declined due to the inflationary pressures during this timeframe, akin to a nominal wage cut. Following a period of stagnation, there was a renewed phase of nominal wage growth, culminating in 600 euros by 2019, with an annual increase in real wages of 4.2%, outpacing the annual average real wage growth at 0.5%. Consequently, the proportion of workers covered by the minimum wage significantly increased, rising from 12 to 22.1% between 2014 and 2019—a rise of more than 10 percentage points.

This paper contributes to the literature by assessing how the volatility in changes in the minimum wage contributes to strengthening or weakening the relationship between wages and productivity in Portugal. Following the work of Berlingieri et al. (2017), entitled *The Great Divergence(s)*, this paper estimates the relationship between wage and production dispersions between-firms within each sector, using a fixed-effects regression with data from Central Balance Sheet Harmonized Panel Data provided by Banco de Portugal. We take advantage of the sizeable minimum wage adjustments in Portugal recently to apply Berlingieri et al. (2017)'s methodology to this country, to study how the minimum wage affects the productivity-wage nexus. We also depart from apply Berlingieri et al. (2017) study in the following respects: Portugal was initially excluded from their analysis, we use a wider timeframe (from 2006-2019), and we add structural and compositional controls to the conditional correlation between productivity and wages with minimum wage effects.

We offer the following novel results. On one hand, while Berlingieri et al. (2017) found "that wage dispersion is linked to increasing differences between high and low productivity firms", we show that in the Portuguese context, there is only a correlation between wage and productivity at the bottom of wage and distribution (i.e., below the median). Moreover, we find evidence that on average a 1% increase in productivity results in a 0.14% increase in wage dispersions, a more modest result compared to the 0.42% found by the authors.

There is evidence that this effect is indirectly driven by increases in the minimum wage, a result robust to the inclusion of controls. Notably, we find no evidence using the nominal minimum wage but rather, increases in the minimum wage are only significant through their ratio with the average wage of each sector. Finally, these effects are present and significant only in the service sector.

The remaining of this essay is structured as follows: Section 2 reviews the literature on the connections between productivity, income inequality, and the minimum wage; Section 3 describes the methodology and provides information on the data and estimation; Section 4 provides a preliminary analysis of the measures of dispersion, Section 5 presents the findings and analysis and robustness, and Section 6 concludes the paper with some closing thoughts.

2. Literature Review

A The generally acknowledged conclusion that observationally similar enterprises display significant variability in measured productivity has been broadly established in empirical literature, as reviewed by Syverson (2011). Simultaneously, the main driver of income inequality stems from increases in between, rather than within-firm wage differences, as evidenced by broad international evidence[4], including Portugal (Card, 2015).

The extent to which disparities in productivity directly affect wages has gained traction, with evidence suggesting that developments in aggregate salary dispersion closely mirror trends in the dispersion of productivity between firms (Dunne et al. 2004; Faggio et al. 2010). Two major arguments support how changes in productivity between firms spill over to divergence in their respective wages: one suggesting that the variation can be attributed to differences in inputs, such as the composition of the workforce and the quality of productive resources, as predicted by a basic competitive model (Murphy and Topel, 1990); while another viewpoint argues that the systematic fluctuation in productivity among companies produces different profits that are shared with their employees through 'rent sharing' (Machin et al. 2003), implying that workers of high profit - high productivity firms enjoy a higher wage and have been supported by empirical observation (Card et al., 2014, Christensen and Bagger 2014).

One of the avenues through which differences in productivity affect wage differentials includes skill-biased technological change, through the rise of information and communication technologies (ICT) (Card and DiNardo, 2002; Faggio et al., 2010; Autor and Acemoglu, 2011). Another avenue is globalization via integration in international trade with increased competition (Feenstra and Hanson 1996, Melitz, 2003). These channels affect the wage dispersion via an expansion of relative demand for skilled labour, increasing their relative wage and, consequently, a rise in wage dispersion driven by productivity.

A central reference of this paper is Berlingieri et al. (2017), which provides a cross-country analysis of over 16 OECD countries from 2002 to 2012 using aggregate micro-level data, founding an overall trend of increased wage dispersion and productivity dispersion between firms, and establishing a positive correlation between the two. Moreover, wage dispersion and productivity dispersions are consistently found between differences in pay/productivity within sectors rather than systematic differences across sectors. This correlation is more accentuated by the differences between each sector's top and bottom firms. Moreover, the authors find evidence of a conditional correlation between minimum wage policies, which reduce wage inequality and simultaneously lead "to a strengthening of the link between productivity and wage dispersion over time."

For Portugal, Card (2018) found rent-sharing elasticities of similar magnitude to previous studies, using matched employer-employee data between 2005 and 2009, implying that labour is supplied inelastically allowing firms to set wages unilaterally and according to their profits. A broader analysis, comprising the 1988 to 2013 period, has shown an eroding link between high-productivity firms and higher wages (Portugal et al. 2018). The technological-based modernization of the labour market transformation has significantly contributed to the broadening of wage dispersion (Cardoso 1997; Centeno and Novo 2014) but the compositional effects of labour do not translate directly, with substantial improvements in the increase of education levels of Portuguese workers (Machado and Mata 2005) eventually leading to a devaluation of intermediate skill workers comparatively to lower-skilled, compressing of the bottom of the wage distribution (Centeno and Novo 2014).

Policies such as the minimum wage affect the wage distribution. First, and the most intended distributional effect of the minimum wage, is mainly concerned with the compression of the lower end of the distribution. This effect is referred to as minimum wage "bite": increasing the wage of those earning bellow the newly established minimum wage on the bottom of the distribution closer to the median, effectively reducing the overall dispersion of wages (Meyer and Wise 1983, Freeman 1996). This effect is present in the successive increases in minimum wage within the Portuguese context over the last two decades, with evidence arguing that it significantly reduced the wage gap (Campos Lima et al. 2021, Oliveira 2022). Second, there are adverse

[4] Evidence for Brazil (Helpman et al., 2017), Denmark (Bagger et al., 2013), Germany (Baumgarten, 2013; Goldschmidt and Schmieder, 2015), Sweden (e.g. Hakanson 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).

employment effects that arise from increases in the minimum wage through job destruction, which reduce wage inequality through the omission of workers with otherwise lower wages - the Portuguese context provides evidence of small disemployment effects (Portugal and Cardoso 2006; Centeno et al. 2014)[5]. Third, there are possible spillovers to higher wages through the increases in wages regarding their relationship with the minimum wage (Grossman 1983).

Concerns with the relationship between the minimum wage and profitability, and consequently productivity, are less common in the literature, with existing papers pointing to a negative impact on firms' profitability, with evidence for the UK (Draca et al. 2011; Bell and Machin 2018), Hungary (Harasztosi and Lindner 2019), US (Chava et al. 2019), and also within the Portuguese context, which was magnified for financially distressed firms unable to endure the costs of the minimum wage (Alexandre et al. 2022).

The negative impact of these effects does not translate directly into decreased productivity. Alexandre et al. (2022) states that "minimum wage policies might have had a supply-side effect. The exit of lower productivity firms caused by the increase in wage costs might have worked as a cleansing effect contributing to higher aggregate productivity", a mechanism also found by Mayneris et al. (2014) without disemployment effects in China. Another mechanism, more in line with the competitive model, is that the minimum wage promotes a fundamental structural and compositional change within firms, leading to increases in productivity (Riley and Bondibene, 2015).

3. Methodology

Com To study the link between wage and productivity divergences, and specifically, assess how the minimum wage as a public policy tool shapes the relationship between them, we rely on Berlingieri et al. (2022)'s methodology, modified appropriately for the single country set-up.

3.1. Data

This article uses data from the Central Balance Sheet Harmonized Panel Data provided by Banco de Portugal, which gathers economic and financial information on Portuguese non-financial corporations, collected and harmonized from Informação Empresarial Simplificada, from 2006 to 2019. The dataset provides information on the financial indicators of a firm, such as turnover, intermediate costs (measured as costs of goods sold and external services), capital stock (fixed tangible assets and intangible assets); as well as information on the number of employees (remunerated, part-time, and full time) and finally the annual combined remuneration of all workers. Additionally, the Portuguese National Accounts were used to derive the annual implicit deflators for gross output, value-added, intermediate costs, and Consumer Price Index, to obtain the real value of the variables of interest.

The data is cleaned to include only firms with open activity, excludes the opening and closure years of firms as they are not representative of a firm's performance; with positive salaries and over 3 workers to reduce bias (this filtering method is employed by Correia and Gouveia (2016) for the same database). The excluded observations account for 70% of the observations, resulting in 1,635,975 observations.

3.2. Preliminary Estimates

A Some additional variables are needed to perform this analysis. Firstly, we calculate the average wage of each firm by averaging the annual salaries (without board compensations nor social security compensations) by the number of workers using a full-time equivalent. Full-time equivalents (FTE) are estimated by adding full-time workers and multiplying part-time workers by half.

We also estimate Total Factor Productivity (TFP) following Wooldridge (2009). Thus, TFP is estimated as a proxy for productivity, capturing the portion of production not explained by the allocation of labour

[5] Centeno (2014) estimates that a 1 percentual point increase in the minimum wage decreased employment of minimum-wage earners by 1.1 percent point.

and capital in the production function – its efficiency. It provides a more comprehensive and long-term economic growth industry-level measure. Assuming a Cobb-Douglas production function:

$$Y_{it} = A_{it} K_{it}^{\beta_K} L_{it}^{\beta_L} \quad (1)$$

an OLS estimation of the TFP would yield biased results given that it would imply endogeneity of the inputs the production function, due to simultaneity bias, since labour and capital are determined by the characteristics of the firm - which include efficiency (Marschak and Andrews, 1994). Wooldridge (2009), like Levinsohn-Petrin (2003), overcomes the endogeneity with an instrumental variable approach, namely, using intermediate costs as a proxy measure for productivity, and applying a polynomial of lagged inputs and intermediates. We estimate the productivity of each firm by applying the TFP Wooldridge method using the STATA command *prodest* within each sector separately (Rovigatti 2018):

$$\mathrm{y_{it}} = \beta_0 + \beta_k \mathrm{k}_{it} + \gamma \mathrm{l_{it}} + \beta_m \mathrm{m_{it}} + \mathrm{m}_t^{-1}(\mathrm{k_{it}}, \mathrm{m_{it}}) + \mu_{it} + e_{it} \quad (2)$$

where y_{it} is output proxied as gross value added, capital $k_{it}$is fixed tangible assets plus intangible assets, labour l_{it} is full-time equivalents, and m_{it} materials are proxied via supplies and external services, for each firm *i* in year *t*[6]. The variable of interest, productivity, equals the sum of the observable residual μ_{it} and the constant β_0, with all the parameters being estimated simultaneously using moment conditions[7].

We measure wage and productivity inequality based on the 90-10, 90-50, and 50-10 percentile log differences. These measures capture the differences in the overall, top, and bottom of the distribution. We apply the 3 measures of wage and productivity dispersion using the average annual wage and TFP, respectively, and calculate it for each 2-digit sector.

Finally, to control for the globalization hypothesis, we create a dummy for each sector with the total exports comprising more than half of the total turnover. The Percentage of minimum wage workers[8] and skill composition[9] are only available at the letter sector level.

Table 1 –*Descriptive Statistics. Panel A describes the variables used to estimate the variables of interest. Panels B, C and D describe the deflated estimated variables for each 2 digit-sector/year.*

DESCRIPTIVE STATISTICS					
VARIABLES	*Obs.*	*Mean*	*Std. Deviation*	*Min*	*Max*
(A) Sample Variables					
Full-Time Equivalents	1, 635,975	19.621	136.1213	0	23968.5
Worker's Remuneration	1,635,975	262595.8	2380840	1.41	526000000
TFP Residual	1,500,389	9.62	0.9233559	-3.325275	17.39835
Fixed Tangible Assets+ Intangible Assets	1, 635,975	1103667	31400000	-390	7940000000
Turnover	1, 635,975	2497999	38000000	76	9630000000
Costs of Goods Sold	1,635,975	1358191	30500000	0	8720000000
Supplies and Service	1,635,943	588835.5	8673648	0	2480000000
Exports	1, 635,975	509475.1	14200000	0	3690000000
(B) Wage Dispersion					
90-10 log Wage Ratio	1,166	1.299	0.419	0	3.761
90-50 log Wage Ratio	1,166	0.636	0.243	0	2.353
50-10 log Wage Ratio	1,166	0.663	0.246	0	3.544
(C) Productivity Dispersion					
90-10 log MFP Ratio	1,064	2.012	0.739	0.660	8.450
90-50 log MFP Ratio	1,064	1.016	0.454	0.190	3.653
50-10 log MFP Ratio	1,064	0.996	0.398	0.272	7.385
(D) 2-digit sector variables					
Nominal Minimum Wage	1,166	489.95	60.387	385.9	600
Relative Minimum Wage	1,166	0.844	1.125	0.170	34.216
Capital Intensity (Sector Mean)	1,166	16.338	2.121	5.227	20.440
Exporter Status	1,166	0.168	0.374	0	1
Log Turnover	1,162	20.658	2.156	5.666	24.837
Perc. MW Workers	1,026	0.136	0.099	0	0.424
Perc. High Skill Workers	1,072	0.205	0.172	0.032	0.667

3.3. Estimation

Na The relationship between productivity and wages is estimated using the following fixed effects regression that relates wage dispersion and productivity dispersion for each difference in percentiles:

$$WD_{jt} = \alpha + \beta \cdot PD_{jt} + y_t + z_j + \epsilon_{jt} \quad (3)$$

where WD_{jt} denotes wage dispersion, measured by the difference in logged wage percentiles, PD_{jt} denotes productivity dispersion measured by the logged differences in TFP, y_t and z_j indicate respectively year and two-digits sector fixed effects, for each year t and 2-digit sector j. Given that average wage and TFP dispersions are micro-

[6] Sectors with less than 100 observations were dropped due to small sample size.

[7] A more detailed explanation of the moment conditions can be found in Wooldridge (2009).

[8] Percentage of minimum wage workers retrieved from GEP, MTSSS, Inquérito aos Ganhos e à Duração do Trabalho anual reports. Further information on http://www.gep.mtsss.gov.pt/inqueritos.

[9] Skill composition retrieved from INE online database. Further information available on https://www.ine.pt/.

aggregated moments from firm-level data, each observation jt is analytically weighted by the number of firms, in accordance with Berlingieri et al. (2022).

Afterwards, minimum wage effects were added:

$$WD_{jt} = \alpha + \beta \cdot PD_{jt} + \gamma \cdot C_{jt} + \delta \cdot (PD \cdot C)_{jt} + y_t + z_j + \epsilon_{jt} \quad (4)$$

where MW denotes the minimum wage either measured by the nominal minimum wage for each year or the minimum wage relative to average wage per FTE, regressed separately, for each year t and 2-digit sector j. In fact, for sectors with a high percentage of workers receiving the minimum wage, we would expect the wage dispersion of the bottom quantile of the productivity distribution to be more compressed in comparison to other sectors.

Finally, we add controls to the last equation:

$$WD_{jt} = \alpha + \beta \cdot PD_{jt} + \gamma \cdot MW_{jt} + \delta \cdot (PD \cdot MW)_{jt} + \theta \cdot \mathbf{X}'_{jt} + y_t + z_j + \epsilon_{jt} \quad (5)$$

with $\mathbf{X}'$ denoting a vector of time-varying controls for turnover, percentage of high-skill workers, exporter status, percentage of minimum wage workers, and their respective interaction with productivity dispersion (except turnover) for each 2-digit sector j in each year t.

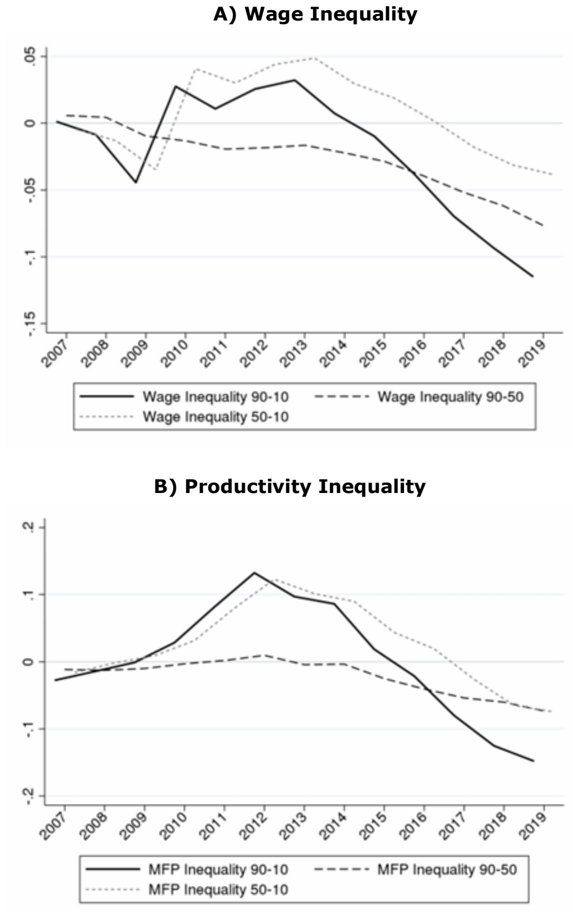
4. Preliminary Analysis

The initial focus of this research centres on the evolution of wage and productivity dispersions using the following equation weighted by the number of firms in each sector:

$$(logY_{90} - logY_{10})_{jt} = \alpha + \beta_t year_t + z_j + \epsilon_{jt} \quad (6)$$

where Y_{90} and Y_{10} are respectively the 90th and 10th percentiles of the dependent variables (average wage per full-time employee and the MFP residual) regressed on year dummies, while controlling for a dummy vector of 2-digit industry sector fixed effects z_j. This specification allows to disentangle the average dispersion in each year β_t from the compositional effects of specific industries.

Figure 1 – Wage and Productivity Inequality measures.



These figures plot the coefficient β_t from equation 6, controlling for 2-digit sector fixed effects and analytical weights for the number of firms in each sector.

This analysis starts with an examination of the 90-10 percentiles, which offers insights into the broader economic context, to discern the prevailing patterns and trends shaping the economy. As evidenced by the figures above, the evolution of wage and productivity dispersions follows a relatively similar pattern. There is a period of increased inequality concurrent with the effects of the 2008 financial crisis, where heterogeneity in productivity and wages increased among firms within the same sector in a period of high job destruction and all-time high unemployment rates (Carneiro et al., 2014). By 2016, the overall dispersions had returned to their 2010 levels and continued to decrease.

The upper quantiles seem unaffected by these effects, as the wage 90-50 percentile difference has been on a steady decline since 2007, while changes in productivity have remained close to 0 until 2015, after which began decreasing. Conversely, the 50-10 percentile difference follows the 90-10 percentile differences with a more accentuated decrease after 2013.

Overall, the evolution of wage and productivity indicates that the link between firm-level wages and productivity is mainly driven by the lower quantiles, with the 90-10 percentile difference closely mimicking the behaviour of the 50-10. Additionally, the aforementioned decrease in wage/productivity inequality in the upper percentiles seems to mitigate the crisis effects on the overall distribution, which are more pronounced and longer lasting in the bottom percentiles. This can be related to the fact that at the top there is more competition for talent, in particular for managers, despite the crisis.

5. Results

Este We now move to the identification of a potential relationship between productivity and wage dispersions by using the baseline specification (3): regressing the wage dispersion on productivity dispersion while controlling for year-sector fixed-effect found in Table 1.

Table 2 – **Estimated coefficients of productivity divergence.**

	WAGE-PRODUCTIVITY DIVERGENCE		
VARIABLES	(1) *Wage Divergence 90-10*	(2) *Wage Divergence 90-50*	(3) *Wage Divergence 50-10*
Productivity Divergence	0.0722 (0.0797)	0.0389 (0.0711)	0.143* (0.0379)
Observations	1064	1064	1064
R-squared	0.943	0.958	0.875
Year-Sector FE	Yes	Yes	Yes

This table reports the fixed-effects regression estimates for the β in equation (3). Productivity Divergence refers to the productivity difference of percentiles stated in the dependent variable.

Standard errors clustered at the 2-digit sector level reported in brackets: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The initial results point only to a statistically significant positive relationship on the 50-10 percentile difference. More specifically, on average, an increase of one percentage point in the dispersion of productivity between the 50th and 10th percentile is correlated with a 0.14 percent increase in logged wage dispersion per worker, within the same percentile difference, between firms within the same sector, ceteris paribus. On the top of the wage distribution, we fail to find evidence of a significant correlation with productivity.

The evolution of productivity dispersion when considering 50-90th percentiles differences follow a remarkably similar pattern until 2014, after which median firms (50th percentile) outperformed the growth in productivity of the top firms, which have remained close to zero and even dipped below it [Graph 2 in annex]. Simultaneously, average wages have steadily been increasing in the 50th-90th percentile differences. These results are consistent with Portugal (2018), implying a decoupling of wages from productivity stemming from higher-performance firms being able to sustain increases in their average wages without increasing their productivity. This result contradicts the rent sharing hypothesis as the wages of high-performing companies are not a result of distributing their profits and rents to their employees directly through their salary, but rather directing these benefits independent of productivity.

Overall, the combined impact of the top and bottom distribution results in the non-statistical significance on the overall economy measured by the 90-10 percentile difference. This result points to the existence of a dual economy, where at the bottom of the distribution there is a productivity-driven wage increase and at the top of the distribution wages have increased independently. The reshaping of the wage distribution over the last two decades was also structurally driven by minimum wage policies, as stated by Oliveira (2021), where the wage inequality reduction mechanism was not relegated to the minimum wage bite but also shifted the wage distribution to the right, due to spillovers effects.

We now turn to the role of the minimum wage, by adding two national minimum wage controls to the regression per specification (4): the nominal and relative minimum wage, and their interaction with productivity (Table 2). The relative minimum wage measures how close the average nominal wage is to the minimum wage of the country for each period, allowing to disentangle how changes in the minimum wage affect each sector individually.

Table 3 – Estimated coefficients of productivity divergence with controls for nominal and relative minimum wage.

Relationship between the Wage-Productivity Divergence and the Minimum Wage

VARIABLES	(1) Wage Divergence *90-10*	(2) Wage Divergence *90-10*	(3) Wage Divergence *90-50*	(4) Wage Divergence 90-50	(5) Wage Divergence *50-10*	(6) Wage Divergence *50-10*
Prod. Diver.	0.0915 (0.164)	0.0254 (0.0941)	-0.00945 (0.104)	0.0310 (0.0739)	0.0655 (0.189)	0.0732 (0.0546)
Nominal MW	-0.0722 (0.0690)		-0.0755*** (0.0202)		-0.0450 (0.0500)	
NMW x PD	-0.00745 (0.0434)		-0.0195 (0.0238)		0.0279 (0.0675)	
Relative MW		-0.0445* (0.0224)		-0.00389 (0.00519)		-0.0353** (0.0164)
RMW x PD		0.0437* (0.0211)		-0.00899 (0.0112)		0.0612** (0.0269)
Observations	1064	1064	1064	1064	1064	1064
R-squared	0.943	0.944	0.959	0.958	0.875	0.878
Year-Sector FE	Yes	Yes	Yes	Yes	Yes	Yes

This table reports the fixed-effects regression estimates for equation (4): coefficients γ and δ are reported in the second and third rows for the nominal minimal wage and in the fourth and fifth rows for the relative minimum wage, regressed separately. Estimates for the Productivity Divergence refers to the productivity difference of percentiles stated in the dependent variable.

Standard errors clustered at the 2-digit sector level reported in brackets: $*$ $p < 0.1$, $**$ $p < 0.05$, $***$ $p < 0.01$.

The first result is that the wage and productivity dispersion relation is broken when considering minimum wage policies (nominal and relative minimum wage) in all percentile differences, as evidenced by the first row. However, a sectorial increase of the relative minimum wage has the intended effect of reducing wage inequality by decreasing wage dispersion both under 90-10 and 50-10 percentiles (negative relative minimum wage coefficient) and simultaneously is associated with an increase in the correlation between wage and productivity dispersions (positive relative minimum wage times productivity dispersion coefficient), reversing the effect of wage compression brought on by the first effect.

This result implies that changes in the minimum wage have an impact on wage dispersion between firms, conditional on their relationship with the average wage of each sector and have contributed to strengthening the relationship between wages and productivity at the bottom of the distribution. Berlingieri (2017) offers some explanations for these results: the exit of less productive firms from the bottom of the productivity distribution; a reduction of labour inputs via misemployment effects or labour-capital substitution, and productivity-enhancing compositional change of the workforce. The first explanation is consistent with those found by Portela (2022), with increases in the minimum wage exhibiting magnified adverse consequences on both profitability and employment for financially distressed firms unable to sustain the minimum wage increases, leading to their closure. This provides a supply side explanation that would lead to increases in productivity.

Moreover, there's little evidence of a relationship between minimum wage and productivity on the top of the distribution, but according to Table 2, an increase of 1% of the nominal minimum wage is associated with a decrease of wage dispersion by 0.0755%. These results corroborate that the minimum wage, by affecting relative wage, directly has an impact on the productivity of low-wage firms but fails to stimulate productivity growth on the top of the distribution, exhibiting only distributional effects at best.

Taken as a whole, these results indicate that the positive relationship between wage dispersion and productivity dispersion captured in Table 1 is indirectly driven by the effect of minimum wage on the relative wage.

Robustness Checks

5.1. Structural and Compositional Effects

To further investigate the relationship between productivity and wages, we first control for structural and compositional effects of the sectors that shape the correlation between wages and productivity across sectors. We add variables to control for the effects of globalisation via a dummy for export-intensive sectors, skill composition by the share of workers skill workers (higher education), and capital intensity[10]. The rationale behind these controls is to account for the skill-biased technological modernization of the Portuguese labour market - proxied via the skill of workers - and account for labour-capital substitution via capital intensity.

[10] One important limitation of this analysis is lack of variables to control for ICT with the current dataset.

Using the baseline regression (4), we sequentially introduce each of these controls and evaluate their statistical significance separately from minimum wage variables (Table 6 in annex). As expected, most of the control variables are significant in explaining the wage-productivity nexus and establish a significant correlation with wage dispersion[11]. In contrast, capital intensity exhibits no statistical significance, suggesting that firms' investment does not influence the relationship between productivity and wage dispersion and capital-labour substitution is not a determining factor in this period. Moreover, this variable can be collinear with productivity, given that it was used as an input.

Consequently, we introduce the controls excluding capital intensity, according to equation (6), to assess the robustness of the minimum wage on estimates.

Table 3 shows that the results are robust to the inclusion of the new controls. Notably, the explanatory power of the relative minimum wage within each sector persists. The coefficient of the isolated productivity divergence, which was previously insignificant, now attains statistical significance at the 90-10 and 50-10 percentile difference.

Additionally, there's evidence that sectors more exposed to the minimum wage are prone to higher wage inequality between firms compared to sectors less exposed, both on the bottom and overall distributions since the positive coefficient of the percentage of minimum wage workers is positive and statistically significant. Nonetheless, increases in the minimum wage continue to exert a positive effect in reducing wage inequality and correlate with increases in productivity in the 50-10 percentile differences. The wage-biting effects, when accounting for the differences between the top and lowest performing firms, do come at a cost of reduced correlation between productivity and income.

Table 4 – Estimated coefficients of productivity divergence with controls for nominal, relative minimum wage plus sectorial structural and compositional controls.

Structural and Compositional Effects						
VARIABLES	(1) Wage Divergence *90-10*	(2) Wage Divergence *90-10*	(3) Wage Divergence *90-50*	(4) Wage Divergence 90-50	(5) Wage Divergence *50-10*	(6) Wage Divergence *50-10*
Prod. Diver.	0.187*	0.0947**	0.144	0.0186	0.162	1.33***
	(0.112)	(0.0466)	(0.0895)	(0.0417)	(0.176)	(0.0557)
Nominal MW (NMW)	-0.0762		-0.000384		-0.0747	
	(0.0810)		(0.0294)		(0.0617)	
NMW x PD	-0.0253		-0.0603		0.00977	
	(0.0467)		(0.0389)		(0.0673)	
Relative MW (RMW)		-0.0344*		0.00215		-0.0240**
		(0.0180)		(0.0045)		(0.0105)
RMW x PD		0.0336*		-0.00395		0.0419**
		(0.0169)		(0.00951)		(0.0173)
Turnover	-0.0771	-0.0721	-0.0347**	-0.0349**	-0.0250	-0.0227
	(0.0503)	(0.0501)	(0.0179)	(0.0183)	(0.0352)	(0.0353)
High Skill (HS)	-0.397	-0.422	-0.613***	-0.565***	0.0518	0.00113
	(0.323)	(0.336)	(0.180)	(0.199)	(0.238)	(0.243)
HS x PD	0.0819	0.0669	0.496***	0.402***	-0.225**	-0.164
	(0.103)	(0.0957)	(0.106)	(0.102)	(0.110)	(0.133)
Exporter Status (ES)	-0.158**	-0.163**	-0.0363	-0.0267	-0.0392	-0.0475
	(0.0622)	(0.0626)	(0.0268)	(0.0246)	(0.0535)	(0.0517)
ES x PD	0.0916**	0.0940**	0.0533*	0.0418	0.0347	0.0440
	(0.0371)	(0.0370)	(0.0311)	(0.0285)	(0.0681)	(0.0651)
Perc. MW Workers	0.456	0.641**	-0.0698	-0.0773	0.286	0.304*
	(0.335)	(0.278)	(0.109)	(0.0691)	(0.172)	(0.181)
%MW x PD	-0.166	-0.272**	0.0156	-0.165*	-0.0398	-0.0543
	(0.169)	(0.121)	(0.145)	(0.0927)	(0.172)	(0.205)
Observations	903	903	903	903	903	903
R-squared	0.959	0.960	0.970	0.970	0.897	0.898
Year and Sector FE	Yes	Yes	Yes	Yes	Yes	Yes

This table reports the fixed-effects regression estimates for equation (5). Estimates for the Productivity Divergence refers to the productivity difference of percentiles stated in the dependent variable.

Standard errors clustered at the 2-digit sector level reported in brackets: $*$ $p < 0.1$, $**$ $p < 0.05$, $***$ $p < 0.01$.

The inclusion of controls also contextualizes the previous findings. First, there is evidence for the globalization hypothesis, measured through the exporter status of sectors, as an important driver of reducing wage inequalities and improving the correlation with productivity between the top and bottom percentiles (90-10p). The intensity of exports is, therefore, an important differentiating factor between sectors and acts through compressing of the overall wage distribution of the top and bottom performing firms within each sector

The addition of labour composition controls complements the previously insignificant relationship at the top half of the distribution, highlighting high skill as the predominant factor shaping the correlation between income and productivity across sectors. Having a higher qualified workforce leads to a reduction of wage dispersion at the top, but at the same time (although at a lower degree) it also

[11] Looking to the composition of the labour force, the share of high-skill workers exhibits a consistent level of significance across all percentile differences while the relevance of exports and the percentage of minimum wage workers are restricted to the 90-10 and 90-50 percentile differences.

increases wage dispersion via the effect on productivity.

Furthermore, the interaction between the percentage of minimum wage workers and productivity is found to be significant for the 90-50 percentiles, suggesting that sectors more exposed to the minimum wage experience a weaker correlation between wages and productivity, although not through changes in the nominal or relative value of the minimum wage directly. This result implies the inability of changes in the minimum wage to stimulate productivity and only accumulate wage bite effects within sectors.

Overall, these results show that the minimum wage effects are consistent and the main explanatory factor in the bottom half of the distribution, while at the top of the distribution, there are only minimum wage biting effects.

5.2. Industry Differences

To carry out a more comprehensive examination of the interplay between salaries and productivity, we provide an analysis only for the manufacturing or service sectors, utilizing the minimum wage specifications both with and without structural and compositional controls.

The findings in Table 4 for the service sector are consistent with the previous results. Relative minimum wage effects remain significant and of similar magnitude for the bottom half of the distribution when controlling for structural effects; and the workforce's qualifications remain the primary driving force behind the correlation between wages and productivity between sectors at the top of the distribution. Furthermore, we observe once again that the results for the overall economy are driven by the bottom of the distribution, with the relative minimum wage effects being transposed to the 90-10 percentile difference.

However, the results for the manufacturing sector do not share the same consistency (Table 5). There is a negative correlation between wage and productivity at the top half of the distribution that persists with the introduction of the nominal minimum wage (Table 8 in annex). These effects, however, disappear when we control for structural and compositional effects. Additionally, we do not find any evidence of a robust correlation between wages and productivity or minimum wage effects at the bottom of the distribution.

Table 5 – Estimated coefficients of productivity divergence with controls for nominal, relative minimum wage plus sectorial structural and compositional controls.

STRUCTURAL AND COMPOSITIONAL EFFECTS - SERVICE SECTOR

VARIABLES	(1) Wage Divergence *90-10*	(2) Wage Divergence *90-10*	(3) Wage Divergence *90-50*	(4) Wage Divergence 90-50	(5) Wage Divergence *50-10*	(6) Wage Divergence *50-10*
Prod. Diver.	0.194	0.173***	0.172	0.114***	-0.0113	0.119*
	(0.136)	(0.0325)	(0.119)	(0.0406)	(0.232)	(0.0605)
Nominal MW (NMW)	-0.133		-0.0296		-0.147	
	(0.120)		(0.0398)		(0.0998)	
NMW x PD	0.00920		-0.0259		0.0890	
	(0.0630)		(0.0494)		(0.0978)	
Relative MW (RMW)		0.0357**		-0.00170		-0.0294*
		(0.0176)		(0.00482)		(0.0157)
RMW x PD		0.0388**		0.00380		0.0499*
		(0.0165)		(0.0105)		(0.0259)
Turnover	0.0258	0.0311	0.0116	0.0131	0.0403	0.0418
	(0.0480)	(0.0471)	(0.0250)	(0.0251)	(0.0271)	(0.0273)
High Skill (HS)	-0.311	-0.413	-0.449**	-0.430**	0.0353	-0.124
	(0.380)	(0.344)	(0.185)	(0.195)	(0.311)	(0.283)
HS x PD	-0.0475	-0.00192	0.291**	0.254**	-0.334**	-0.164
	(0.131)	(0.0929)	(0.126)	(0.118)	(0.124)	(0.128)
Exporter Status (ES)	-0.197**	-0.214***	-0.0390*	-0.0331	-0.0571	-0.0678
	(0.0785)	(0.0709)	(0.0201)	(0.0155)	(0.0628)	(0.0494)
ES x PD	O. 139***	0.148***	0.0598**	0.0527**	0.105	0.0116**
	(0.0452)	(0.0417)	(0.0250)	(0.0209)	(0.0634)	(0.0492)
Perc. MW Workers	0.654	0.676**	-0.140	-0.0776	0.337	0.192
	(0.424)	(0.327)	(0.138)	(0.0972)	(0.324)	(0.263)
%MW x PD	-0.318	-0.333***	0.0612	-0.0185	-0.112	0.0525
	(0.205)	(0.132)	(0.173)	(0.0956)	(0.269)	(0.218)
Observations	519	519	519	519	519	519
R-squared	0.965	0.965	0.975	0.975	0.889	0.890
Year-Sector FE	Yes	Yes	Yes	Yes	Yes	Yes

This table reports the fixed-effects regression estimates for equation (5) filtered to only include sectors within the service industry. Estimates for the Productivity Divergence refers to the productivity difference of percentiles stated in the dependent variable.
Standard errors clustered at the 2-digit sector level reported in brackets: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 6 – Estimated coefficients of productivity divergence with controls for nominal, relative minimum wage plus sectorial structural and compositional controls.

STRUCTURAL AND COMPOSITIONAL EFFECTS – MANUFACTURING SECTOR

VARIABLES	(1) Wage Divergence *90-10*	(2) Wage Divergence *90-10*	(3) Wage Divergence *90-50*	(4) Wage Divergence 90-50	(5) Wage Divergence *50-10*	(6) Wage Divergence *50-10*
Prod. Diver.	0.0744	0.0438	0.170*	0.0906	0.317	0.226***
	(0.162)	(0.0762)	(0.0848)	(0.0684)	(0.254)	(0.0812)
Nominal MW (NMW)	-0.218		-0.0712*		-0.0495	
	(0.153)		(0.0367)		(0.107)	
NMW x PD	-0.0369		-0.0997**		-0.0576	
	(0.0728)		(0.0463)		(0.130)	
Relative MW (RMW)		0.188*		0.155**		0.129
		(0.101)		(0.0484)		(0.0796)
RMW x PD		-0.0597		-0.129**		-0.0638
		(0.0516)		(0.0563)		(0.0597)
Turnover	-0. 159***	-0. 148***	- 0.0685***	- 0.0699***	- 0.0973***	- 0.0889***
	(0.0408)	(0.0365)	(0.0176)	(0.0183)	(0.0276)	(0.0236)
High Skill (HS)	1.954*	2.3210	0.771	1.175**	0.771	1.011
	(1.127)	(0.940)	(0.465)	(0.438)	(0.769)	(0.643)
HS x PD	0.598*	0.411	0.980*	0.564*	0.338	0.103
	(0.335)	(0.348)	(0.493)	(0.323)	(0.566)	(0.349)
Exporter Status (ES)	-0.0821	-0.0729	-0.0521	-0.0380	0.0388	0.0415
	(0.0860)	(0.0825)	(0.0455)	(0.0454)	(0.0626)	(0.0607)
ES x PD	0.0352	0.0308	0.0652	0.0491	-0.0691	-0.0717
	(0.0487)	(0.0469)	(0.0525)	(0.0530)	(0.0725)	(0.0705)
Perc. MW Workers	0.497	O. 6490	0.0935	0.281**	0.286	0.415*
	(0.495)	(0.303)	(0.120)	(0.137)	(0.352)	(0.231)
%MW x PD	-0.155	-0.214*	-0.0202	-0.247	-0.242	-0.331*
	(0.236)	(0.120)	(0.159)	(0.159)	(0.364)	(0.175)
Observations	384	384	384	384	384	384
R-squared	0.959	0.962	0.970	0.970	0.875	0.881
Year-Sector FE	Yes	Yes	Yes	Yes	Yes	Yes

This table reports the fixed-effects regression estimates for equation (5) filtered to only include sectors within the manufacturing industry. Estimates for the Productivity Divergence refers to the productivity difference of percentiles stated in the dependent variable.

Standard errors clustered at the 2-digit sector level reported in brackets: $* \; p < 0.1$, $** \; p < 0.05$, $*** \; p < 0.01$.

The only minimum wage effects occur at the top half of the distribution, with increases in the nominal value of the minimum wage decreasing wage inequality. Conversely, increases in the minimum wage that increase the ratio of minimum wage to average wage result in an increase in wage inequality, thus implying that the impact of an increase of the minimum wage is conditional on its impact on the relative minimum wage. Minimum wage policies have, therefore, a heterogeneous impact on wage inequality depending on whether workers are employed by firms that are increasing their average wage at a higher rate than that of the minimum wage at the top of the distribution. This result implies that changes in the minimum wage have distributional effects that aren't matched by the productivity indicators, decreasing the correlation between income and productivity (both interaction coefficients are negative).

Remarkably, nominal sand relative minimum wage effects are not statistically significant on the bottom of the distribution. A reduction of labour inputs via disemployment effects might be driving these results, as reported by Lima (2021), where increases in unemployment were more prevalent in this industry during the 2010 and 2013 period, shaping average wages.

Overall, these findings provide valuable insights into the complex interplay between various factors that contribute to the relationship between minimum wage policies and wage and productivity dispersion in different industries: the manufacturing sector in Portugal results in heterogeneous outcomes, while changes to the nominal minimum wage through the relative minimum wage impact the overall economy through the effects on the 50-10 percentile difference of the service sector.

6. Conclusion

Over the last two decades, the minimum wage in Portugal has been through three phases: an increase, followed by stagnation, and finally a new, more sizeable, increase. Overall, increases in the minimum wage have been positively correlated with the relationship between productivity and wages on the 90-10 and 50-10 wage percentile differences, respectively. The minimum wage effects, measured through the relative minimum wage, had two reverse but complementary effects: it has led to a compression of the wage distribution through its wage biting effects and, simultaneously, has led to a strengthening of the correlation between wage and productivity dispersions, between firms within each sector. This conundrum can be explained by the cleansing effect that increases in the minimum wage had by removing unproductive firms from the bottom of the productivity dispersion; the remaining and, thus, more productive firms have persisted. For the persisting firms, a rent-sharing allocation of wages is observed – with higher productivity firms paying on average higher wages within each sector.

The minimum wage is not the sole determinant of wage inequality on the overall wage distribution, the intensity of exports plays a significant part in also explaining differences in wage inequalities between sectors, with export-intensive sectors experiencing on average reduced wage inequality and increase correlation between wages and productivity.

Between the top and median performing firms of each sector, there is no correlation between productivity and wages, given that the wage dispersion has been decreasing, while productivity indicators have remained relatively stable. The only relationship between salaries and productivity is primarily explained by cross-sector differences in education, suggesting that sectors with a higher share of skilled workers experience a stronger correlation between income and productivity. We don't find any evidence of any direct minimum wage effects, either through nominal or relative minimum wage measures for the higher-performing firms.

These results are consistent with the service sectors but do not hold in the manufacturing sectors, with the latter showing heterogeneity the in the outcomes of a minimum wage increase.

An important caveat is that the effects of the minimum wages presented are measured through their impact on the ratio with the average wage. This is an important result for policymaking, as increases in the nominal wage should, therefore, take into consideration the average wage and the magnitude of its wage-biting effects in each sector to be efficient.

Moving forward, using different estimation methods is of utmost relevance to corroborate the results found in this conditional correlation analysis. The use of instrumental variables would be an interesting solution to solve the possibility of simultaneous bias between productivity and wage dispersion estimates. Moreover, the lack of variables such as ICT, accounting for the entrance and exit of firms, and other decoupling mechanisms of wage and productivity should be complemented in the future.

Referências Bibliográficas:

Alexandre, F., P. Bação, J. Cerejeira, H. Costa, and M. Portela. 2022. "Minimum Wage and Financially Distressed Firms: Another One Bites the Dust." *Labour Economics* 74 (January): 102088. https://doi.org/10.1016/j.labeco.2021.102088.

Correia, A. L. and Ana F. Gouveia (2016). "What determines firm-level export capacity? Evidence from Portuguese firms". *GEE Papers* (57).

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

Bell, Brian, and Stephen Machin. 2018. "Minimum Wages and Firm Value." Journal of Labor Economics 36 (1): 159–95. https://doi.org/10.1086/693870.

Berlingieri, Giuseppe, Patrick Blanchenay, and Chiara Criscuolo. 2017. "The Great Divergence(S)." *OECD Science, Technology and Industry Policy Papers* 39 (May). https://doi.org/10.1787/953f3853-en.

Campos Lima, Maria da Paz, Diogo Martins, Ana Cristina Costa, and António Velez. 2021. "Internal Devaluation and Economic Inequality in Portugal: Challenges to Industrial Relations in Times of Crisis and Recovery." *European Review of Labour and Research, February*. https://doi.org/10.1177/1024258921995006.

Card, D., F. Devicienti, and A. Maida. 2013. "Rent-Sharing, Holdup, and Wages: Evidence from Matched Panel Data." *The Review of Economic Studies* 81 (1): 84–111. https://doi.org/10.1093/restud/rdt030.

Card, David, Ana Rute Cardoso, and Patrick Kline. 2015. "Bargaining, Sorting, and the Gender Wage Gap: Quantifying the Impact of Firms on the Relative Pay of Women *." *The Quarterly Journal of Economics* 131 (2): 633–86. https://doi.org/10.1093/qje/qjv038.

Card, David, Ana Rute Cardoso, Joerg Heining, and Patrick Kline. 2018. "Firms and Labor Market Inequality: Evidence and Some Theory." *Journal of*

Labor Economics 36 (S1): S13–70. https://doi.org/10.1086/694153.

Card, David, and John E. DiNardo. 2002. "Skill-Biased Technological Change and Rising Wage Inequality: Some Problems and Puzzles." *Journal of Labor Economics* 20 (4): 733–83. https://doi.org/10.1086/342055.

Cardoso, Ana Rute. 1997. "Workers or Employers: Who is Shaping Wage Inequality?" *Oxford Bulletin of Economics and Statistics* 59 (4): 523–547.

Centeno, Mário, and Alvaro A. Novo. 2014. "When supply meets demand: wage inequality in Portugal." IZA *Journal of European Labor Studies* 3 (1): 1–20.

Chava, Sudheer, Alexander Oettl, and Manpreet Singh. 2019. "Does a One-Size-Fits-All Minimum Wage Cause Financial Stress for Small Businesses?," *Nber Working Paper Series* 26523. https://doi.org/10.3386/w26523.

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

Draca, Mirko, Stephen Machin, and John Van Reenen. 2011. "Minimum Wages and Firm Profitability." *American Economic Journal: Applied Economics* 3 (1): 129–51. https://doi.org/10.1257/app.3.1.129.

Dunne, Timothy, Lucia Foster, John Haltiwanger, and Kenneth R. Troske. 2004. "Wage and Productivity Dispersion in United States Manufacturing: The Role of Computer Investment." *Journal of Labor Economics* 22 (2): 397–429. https://doi.org/10.1086/381255.

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* 19 (6): 1919–51. https://doi.org/10.1093/icc/dtq058.

Feenstra, Robert C., and Gordon H. Hanson. 1996. "Globalization, Outsourcing, and Wage Inequality." *American Economic Review* 86 (2): 240–245.

Freeman, Richard B. 1996. "The Minimum Wage as a Redistributive Tool." *The Economic Journal* 106 (436): 639–649.

Grossman, Jean Baldwin. 1983. "The Impact of the Minimum Wage on Other Wages." *The Journal of Human Resources* 18 (3): 359–378.

Harasztosi, Peter, and Attila Lindner. 2019. "Who Pays for the Minimum Wage?" *American Economic Review* 109 (8): 2693–2727. https://doi.org/10.1257/aer.20171445.

Levinsohn, James, and Amil Petrin. 2003. "Estimating Production Functions Using Inputs to Control for Unobservables." Review of Economic Studies 70 (2): 317–41. https://doi.org/10.1111/1467-937x.00246.

Machado, José A. F., and José Mata. 2005. "Counterfactual decomposition of changes in wage distributions using quantile regression." *Journal of Applied Econometrics* 20 (4): 445–465.

Machin, Stephen, Alan Manning, and Lupin Rahman. 2003. "Where the minimum wage bites hard: Introduction of minimum wages to a low wage sector." *Journal of the European Economic Association* 1 (1): 154–180.

Mayneris, Florian, Sandra Poncet, and Tao Zhang. 2018. "Improving or Disappearing: Firm-Level Adjustments to Minimum Wages in China." *Journal of Development Economics* 135 (November): 20–42. https://doi.org/10.1016/j.jdeveco.2018.06.010.

Melitz, Marc J. 2003. "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." Econometrica 71 (6): 1695–1725. https://doi.org/10.1111/1468-0262.00467.

Meyer, Robert H, and David A Wise. 1983. "The effects of the minimum wage on the employment and earnings of youth." *Journal of Labor Economics* 1 (1): 66–100.

Murphy, Kevin M., and Robert H. Topel. 1990. "Efficiency Wages Reconsidered: Theory and Evidence." *Advances in the Theory and Measurement of Unemployment*, 204–40. https://doi.org/10.1007/978-1-349-10688-2_8.

Oliveira, Carlos, (2022). "How is the Minimum Wage Shaping the Wage Distribution: Bite, Spillovers, and Wage Inequality". *GEE Papers* (No 0160), Gabinete de Estratégia e Estudos, Ministério da Economia

Portugal, Pedro, and Ana Rute Cardoso. 2006. "Disentangling the minimum wage puzzle: An analysis of worker accessions and separations." *Journal of the European Economic Association* 4 (5): 988–1013.

Portugal, Pedro, Pedro S Raposo, and Hugo Reis. 2018. "The distribution of wages and wage inequality". *Economic Bulletin and Financial Stability*. Banco de Portugal Economics and Research Department.

Riley, Rebecca, and Chiara Rosazza Bondibene. 2017. "Raising the Standard: Minimum Wages and Firm Productivity." Labour Economics 44 (January): 27–50. https://doi.org/10.1016/j.labeco.2016.11.010.

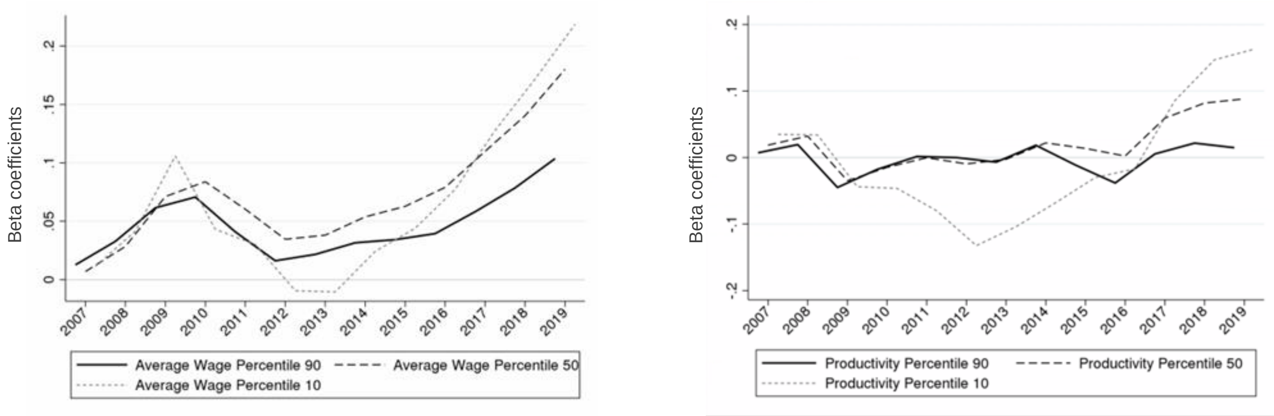
Rovigatti, Gabriele, and Vincenzo Mollisi. 2018. "Theory and Practice of Total-Factor Productivity Estimation: The Control Function Approach Using Stata." *The Stata Journal: Promoting Communications on Statistics and Stata* 18 (3): 618–62. https://doi.org/10.1177/1536867x1801800307.

Wooldridge, Jeffrey M., 2009. "On estimating firm-level production functions using proxy variables to control for unobservables," *Economics Letters*, Elsevier, vol. 104(3), pages 112-114, September.

Additional Graphs:

Figure 2: Wage and Productivity Percentiles Evolution, side by side, respectively.

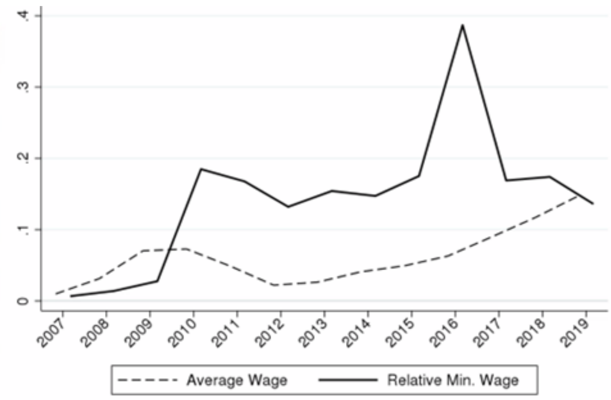
A) Wage Percentile Evolution **B) Productivity Percentile Evolution**



These figures plot the coefficient β_t from equation (5), replacing the difference in percentiles by the percentiles themselves, controlling for 2-digit sector fixed effects and analytical weights for the number of firms in each sector.

Figure 3: Average Wage and Relative Minimum Wage Evolution.

Evolution of Relative Minimum and Average Wage



These figures plot the coefficient β_t from equation (5), replacing the dependent variable with the Annual Average Wage and Relative Minimum Wage, controlling for 2-digit sector fixed effects and analytical weights for the number of firms in each sector.

Additional Tables:

Table 7: Estimated coefficients of productivity divergence with structural and compositional controls regressed individually

	Structural and Compositional Controls														
VARIABLES	(1) Wage Diver. 90-10	(2) Wage Diver. 90-10	(3) Wage Diver. 90-10	(4) Wage Diver. 90-10	(5) Wage Diver. 90-10	(6) Wage Diver. 90-50	(7) Wage Diver. 90-50	(8) Wage Diver. 90-50	(9) Wage Diver. 90-50	(10) Wage Diver. 90-50	(11) Wage Diver. 50-10	(12) Wage Diver. 50-10	(13) Wage Diver. 50-10	(14) Wage Diver. 50-10	(15) Wage Diver. 50-10
Prod. Diver.	0.0722	0.100**	0.0915***	0.134***	0.466	0.0389	0.0791*	0.0163	0.0874***	0.501*	0.143***	0.146**	0.160***	0.151***	-0.0657
	(0.0797)	(0.0941)	(0.0339)	(0.0739)	(0.302)	(0.0711)	(0.0452)	(0.0470)	(0.0404)	(0.296)	(0.0379)	(0.0941)	(0.0231)	(0.0400)	(0.245)
Turnover		-0.0636	-0.0467	-0.0931*	-0.0662		-0.0413**	-0.0270	-0.0526***	-0.0417**		-0.0214	-0.00870	-0.0348	-0.0253
		(0.0523)	(0.0519)	(0.0476)	(0.0519)		(0.0523)	(0.0183)	(0.176)	(0.0182)		(0.0523)	(0.0519)	(0.0343)	(0.0410)
High Skill (HS)		-0.834**					-0.519**					-0.381*			
		(0.387)					(0.225)					(0.224)			
HS x *PD*		0.133					0.405**					-0.101			
		(0.108)					(0.114)					(0.116)			
Exporter Status (ES)			-0.134*					-0.0486					-0.0393		
			(0.0694)					(0.0330)					(0.0497)		
ES x *PD*			0.0720*					0.0669*					0.0258		
			(0.0408)					(0.0395)					(0.0581)		
Perc. MW				0.694**					0.128*					0.279	
				(0.271)					(0.0758)					(0.171)	
%MW x *PD*				-0.240*					-0.107					-0.0031	
				(0.123)					(0.0999)					(0.223)	
Capital Intensity					0.0589					0.0348					-0.00645
					(0.0523)					(0.0253)					(0.0234)
CI x *PD*					-0.0201					-0.0229					0.0122
					(0.0180)					(0.0179)					(0.0136)
Observations	1064	1064	988	953	1064	1064	1064	988	953	1064	1064	1064	988	953	1064
R-squared	0.943	0.952	0.946	0.956	0.946	0.958	0.966	0.961	0.966	0.961	0.875	0.886	0.877	0.893	0.877
Year-Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

This table reports the fixed-effects regression estimates for equation (3) on columns 1, 6 and 7. Additionally, the table reports equation (4) on the remaining columns, including sector turnover and changing the variable of the coefficient γ to high skill, exporter status, percentage of minimum wage workers, and capital intensity; and δ being their respective interactions with productivity. Estimates for the Productivity Divergence and respective interaction refer to the productivity difference of percentiles stated in the dependent variable. Standard errors clustered at the 2-digit sector level reported in brackets: $*$ $p < 0.1$, $**$ $p < 0.05$, $***$ $p < 0.01$.

Table 8 – Estimated coefficients of productivity divergence with controls for nominal, relative minimum wage plus sectorial structural and compositional controls.

	STRUCTURAL AND COMPOSITIONAL CONTROLS 90-10									
INDUSTRY	Manufacturing					Services				
VARIABLES	(1) Wage Divergence *90-10*	(2) Wage Divergence *90-10*	(3) Wage Divergence *90-10*	(4) Wage Divergence *90-10*	(5) Wage Divergence *90-10*	(6) Wage Divergence *90-10*	(7) Wage Divergence *90-10*	(8) Wage Divergence *90-10*	(9) Wage Divergence *90-10*	(10) Wage Divergence *90-10*
Prod. Diver.	-0.0807	-0.293*	-0.0416	0.0744	0.0438	0.210***	0.350***	0.204***	0.194	0.173***
	(0.0659)	(0.165)	(0.0993)	(0.162)	(0.0762)	(0.0166)	(0.0916)	(0.0210)	(0.136)	(0.0325)
Nominal MW (NMW)		-0.206**		-0.218			-0.0141		-0.133	
		(0.0924)		(0.153)			(0.0694)		(0.120)	
NMW x *PD*		0.0826		-0.0369			-0.0549		0.00920	
		(0.0562)		(0.0728)			(0.0384)		(0.0630)	
Relative MW			0.195		0.188*			-0.00468		0.0357**
			(0.134)		(0.101)			(0.0159)		(0.0176)
RMW x *PD*			-0.0441		-0.0597			0.00586		0.0388**
			(0.0721)		(0.0516)			(0.0147)		(0.0165)
Turnover				-0. 159***	-0. 148***				0.0258	0.0311
				(0.0408)	(0.0365)				(0.0480)	(0.0471)
High Skill (HS)				1.954*	2.3210				-0.311	-0.413
				(1.127)	(0.940)				(0.380)	(0.344)
HS x *PD*				0.598*	0.411				-0.0475	-0.00192
				(0.335)	(0.348)				(0.131)	(0.0929)
Exporter Status (ES)				-0.0821	-0.0729				-0.197**	-0.214***
				(0.0860)	(0.0825)				(0.0785)	(0.0709)
ES x *PD*				0.0352	0.0308				O. 139***	0.148***
				(0.0487)	(0.0469)				(0.0452)	(0.0417)
Perc. MW				0.497	O. 6490				0.654	0.676**
				(0.495)	(0.303)				(0.424)	(0.327)
%MW x *PD*				-0.155	-0.214*				-0.318	-0.333***

STRUCTURAL AND COMPOSITIONAL CONTROLS 90-10										
INDUSTRY	MANUFACTURING					SERVICES				
VARIABLES	(1) Wage Divergence *90-10*	(2) Wage Divergence *90-10*	(3) Wage Divergence *90-10*	(4) Wage Divergence *90-10*	(5) Wage Divergence *90-10*	(6) Wage Divergence *90-10*	(7) Wage Divergence *90-10*	(8) Wage Divergence *90-10*	(9) Wage Divergence *90-10*	(10) Wage Divergence *90-10*
				(0.236)	(0.120)				(0.205)	(0.132)
Observations	462	462	462	384	384	602	602	602	519	519
R-squared	0.929	0.932	0.936	0.959	0.962	0.955	0.956	0.936	0.965	0.965
Year-Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

This table reports the fixed-effects regression estimates for equation (3), (4) and (5) filtered to only include sectors within the service industry in columns 1-5, and the same estimates for the manufacturing sectors in columns 6-10 for the 90-10 percentile differences.

Standard errors clustered at the 2-digit sector level reported in brackets: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 9 – Estimated coefficients of productivity divergence with controls for nominal, relative minimum wage plus sectorial structural and compositional controls.

STRUCTURAL AND COMPOSITIONAL CONTROLS 90-50										
INDUSTRY	MANUFACTURING					SERVICES				
VARIABLES	(1) Wage Divergence *90-50*	(2) Wage Divergence *90-50*	(3) Wage Divergence *90-50*	(4) Wage Divergence *90-50*	(5) Wage Divergence *90-50*	(1) Wage Divergence *90-50*	(2) Wage Divergence *90-50*	(3) Wage Divergence *90-50*	(4) Wage Divergence *90-50*	(5) Wage Divergence *90-50*
Prod. Diver.	-0.0596**	-0.138*	-0.0788	0.170*	0.0906	0.209***	0.153***	0.207***	0.172	0.114***
	(0.0244)	(0.0771)	(0.0476)	(0.0848)	(0.0684)	(0.0296)	(0.0523)	(0.0319)	(0.119)	(0.0406)
Nominal MW (NMW)		-0.0786***		-0.0712*			-0.0865***		-0.0296	
		(0.0261)		(0.0367)			(0.0154)		(0.0398)	
NMW x PD		0.0320		-0.0997**			0.0227		-0.0259	
		(0.0339)		(0.0463)			(0.0188)		(0.0494)	
Relative MW			0.00329		0.155**			-0.000874		-0.00170
			(0.0436)		(0.0484)			(0.00476)		(0.00482)
RMW x PD			0.0210		-0.129**			0.00170		0.00380
			(0.0455)		(0.0563)			(0.0104)		(0.0105)
Turnover				-0.0685***	-0.0699***				0.0116	0.0131
				(0.0176)	(0.0183)				(0.0250)	(0.0251)
High Skill (HS)				0.771	1.175**				-0.449**	-0.430**
				(0.465)	(0.438)				(0.185)	(0.195)
HS x PD				0.980*	0.564*				0.291**	0.254**
				(0.493)	(0.323)				(0.126)	(0.118)
Exporter Status (ES)				-0.0521	-0.0380				-0.0390*	-0.0331
				(0.0455)	(0.0454)				(0.0201)	(0.0155)
ES x PD				0.0652	0.0491				0.0598**	0.0527**
				(0.0525)	(0.0530)				(0.0250)	(0.0209)
Perc. MW				0.0935	0.281**				-0.140	-0.0776
				(0.120)	(0.137)				(0.138)	(0.0972)
%MW x PD				-0.0202	-0.247				0.0612	-0.0185
				(0.159)	(0.159)				(0.173)	(0.0956)
Observations	462	462	462	384	384	602	602	602	519	519
R-squared	0.953	0.953	0.954	0.970	0.970	0.968	0.968	0.968	0.975	0.975
Year-Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

This table reports the fixed-effects regression estimates for equation (3), (4) and (5) filtered to only include sectors within the service industry in columns 1-5, and the same estimates for the manufacturing sectors in columns 6-10 for the 90-50 percentile differences.

Standard errors clustered at the 2-digit sector level reported in brackets: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 10 – Estimated coefficients of productivity divergence with controls for nominal, relative minimum wage plus sectorial structural and compositional controls.

STRUCTURAL AND COMPOSITIONAL CONTROLS 50-10

INDUSTRY	MANUFACTURING					SERVICES				
VARIABLES	(1) Wage Divergence *50-10*	(2) Wage Divergence *50-10*	(3) Wage Divergence *50-10*	(4) Wage Divergence *50-10*	(5) Wage Divergence *50-10*	(1) Wage Divergence *50-10*	(2) Wage Divergence *50-10*	(3) Wage Divergence *50-10*	(4) Wage Divergence *50-10*	(5) Wage Divergence *50-10*
Prod. Diver.	0.0773	-0.176	0.182*	0.317	0.226***	0.195***	0.217	0.151***	-0.0113	0.119*
	(0.0606)	(0.210)	(0.103)	(0.254)	(0.0812)	(0.0309)	(0.186)	(0.0538)	(0.232)	(0.0605)
Nominal MW (NMW)		-0.0762		-0.0495			-0.0306		-0.147	
		(0.0530)		(0.107)			(0.0520)		(0.0998)	
NMW x PD		0.0911		-0.0576			-0.00806		0.0890	
		(0.0713)		(0.130)			(0.0668)		(0.0978)	
Relative MW			0.253*		0.129			-0.0209		-0.0294*
			(0.143)		(0.0796)			(0.0178)		(0.0157)
RMW x PD			-0.140		-0.0638			0.0368		0.0499*
			(0.109)		(0.0597)			(0.0292)		(0.0259)
Turnover				-0.0973***	-0.0889***				0.0403	0.0418
				(0.0276)	(0.0236)				(0.0271)	(0.0273)
High Skill (HS)				0.771	1.011				0.0353	-0.124
				(0.769)	(0.643)				(0.311)	(0.283)
HS x PD				0.338	0.103				-0.334**	-0.164
				(0.566)	(0.349)				(0.124)	(0.128)
Exporter Status (ES)				0.0388	0.0415				-0.0571	-0.0678
				(0.0626)	(0.0607)				(0.0628)	(0.0494)
ES x PD				-0.0691	-0.0717				0.105	0.0116**
				(0.0725)	(0.0705)				(0.0634)	(0.0492)
Perc. MW				0.286	0.415*				0.337	0.192
				(0.352)	(0.231)				(0.324)	(0.263)
%MW x PD				-0.242	-0.331*				-0.112	0.0525
				(0.364)	(0.175)				(0.269)	(0.218)
Observations	462	462	462	384	384	602	602	602	519	519
R-squared	0.854	0.858	0.869	0.875	0.881	0.863	0.863	0.864	0.889	0.890
Year-Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

This table reports the fixed-effects regression estimates for equation (3), (4) and (5) filtered to only include sectors within the service industry in columns 1-5, and the same estimates for the manufacturing sectors in columns 6-10 for the 50-10 percentile differences.
Standard errors clustered at the 2-digit sector level reported in brackets: ∗ $p < 0.1$, ∗∗ $p < 0.05$, ∗∗∗ $p < 0.01$.