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PRODUCTIVITY-WAGE NEXUS AT THE FIRM-LEVEL IN PORTUGAL: DECOUPLING AND DIVERGENCES

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ABSTRACT/RÉSUMÉ

Productivity-Wage Nexus at the firm-level in Portugal: Decoupling and Divergences

There is a growing international concern about the slowdown in productivity growth, especially as labor productivity enhancements are important drivers of higher general-ised living standards.

Using administrative data of firms in Portugal between 2010 and 2016, we analyse the relationships between productivity and wages. At odds with neoclassical theory of mar-ginal productivity of labor, we find that two thirds of firms insufficiently raised wages giv-en observed productivity growth. Employing unconditional quantile regressions, we in-vestigate some quantifiable determinants of the productivity-wage gap at different parts of the distributions. Most of the documented dynamics contributed not only to the diver-gence of productivity and wages but also to the decoupling of productivity and wage growth. We argue that labor market flexibilisation intensified segmentation, providing incentives for non standard contracts. Both dimensions, as well as higher board com-pensations, international trade and on-the-job training weakened the link between productivity and wages.

JEL Classification codes: C3, D2, D31, D33, J31, J38.

Keywords: Quantile regressions, productivity, income distribution, wage share, compensation, public policy.

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Articulation entre productivité et salaires au niveau des entreprises au Portugal : découplages et divergences

Le ralentissement de la croissance de la productivité préoccupe de plus en plus à l'échelle internationale, en particulier puisque les hausses de la productivité du travail sont des moteurs importants de l'amélioration généralisée des niveaux de vie.

En nous fondant sur des données administratives collectées au Portugal au niveau des entreprises entre 2010 et 2016, nous avons analysé les relations entre la productivité et les salaires. En contradiction avec la théorie néoclassique de la productivité marginale du travail, nous constatons que deux tiers des entreprises ont insuffisamment augmenté les salaires compte tenu de la croissance de productivité observée. À l'aide de régressions quantiles inconditionnelles, nous étudions certains déterminants quantifiables de l'écart entre productivité et salaires dans différentes parties des distributions. Une très large part de la dynamique documentée a contribué non seulement à faire diverger la productivité et les salaires, mais aussi à découpler la croissance de la productivité de celle des salaires. Nous affirmons que la flexibilisation du marché du travail en a intensifié la segmentation, ce qui a constitué une incitation à établir des contrats non standard. Ces deux dimensions, ainsi que les rémunérations plus élevées des administrateurs, le commerce international et la formation en cours d'emploi ont affaibli le lien entre productivité et salaires.

Classification JEL : C3, D2, D31, D33, J31, J38

Mots-clés : régressions quantiles, productivité, répartition des revenus, part des salaires, rémunération, politique publique

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Productivity-Wage Nexus at the firm-level in Portugal: Decoupling and Divergences

By Alexandre Mergulhão and José Azevedo Pereira[1]

1. Introduction

1. Starting amid the 1990s and the 2000s, advanced economies have been witnessing a slowdown in aggregate productivity growth, which intensified in the post-crisis period. Based on the seminal Cobb-Douglas production function, economic growth can be decomposed into improvements in: labor utilisation, capital used in production and overall efficiency – the latter measured by Total Factor Productivity (TFP). This equates to enhancements in labor productivity (i.e. output per unit of work) and/or in labor utilisation (e.g. total hours worked), whereby enhancements in labor productivity result from either capital deepening and/or improvements in TFP.

2. As labour productivity growth is a long-term driver of economic growth economists and policymakers have become particularly concerned about finding ways to boost it. Namely, the OECD created the Global Forum on Productivity, fostering international research cooperation to assess public policies and best practices. In 2016, the Council of the European Union. issued a recommendation for the establishment of National Productivity Boards to promote a public discussion, based on statistical and economic analysis, on productivity issues. Furthermore, other international institutions have been addressing productivity-enhancing measures, particularly through structural reforms (e.g. WB, 2018; IMF, 2017).

3. This common concern arises from an economic premise that regards productivity as the anchor for generalised rising living standards. However, this assertion is conditional on productivity gains translating into higher wages, for that is the most widespread income source of workers and families. Indeed, around 70% of household income in Portugal derives from wages (ILO, 2018).

4. Furthermore, the link between productivity and wages is not only important for raising the well-being of the median worker. There is a recent and vivid debate on the sources of the “wage puzzle” (Bivens, 2018) – i.e. insignificant wage growth in a period of historically low levels of unemployment/labor market slack. This wage stagnation has implications for the ability of monetary policy to achieve inflation targets. At the ECB Forum of Central Banking, held in Sintra, in 2017, Mario Draghi stated that the structural reforms that reinforced wage bargaining at the firm level might have increased downward but not upward

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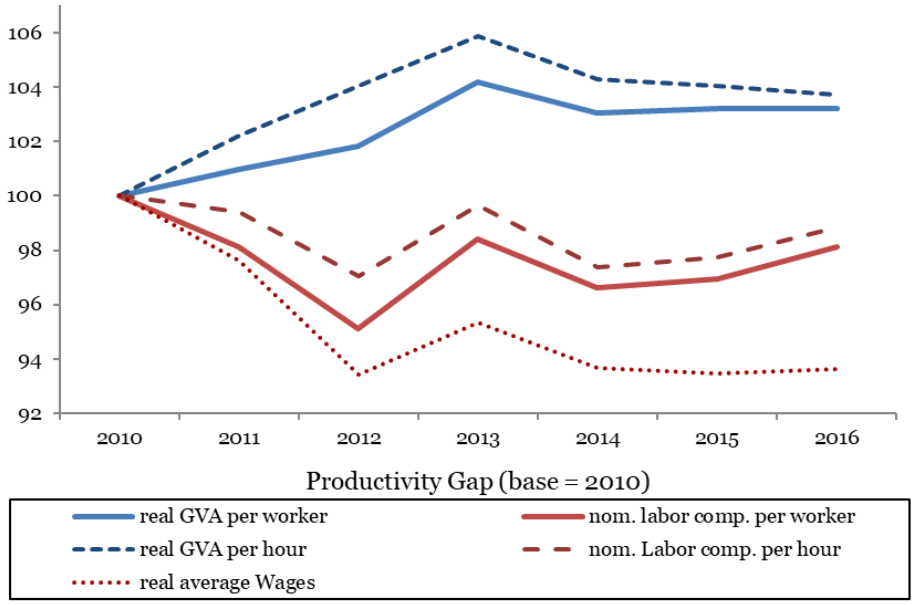
wage flexibility. The president of ECB further added that wage bargaining has changed and one of the reasons for lower wage growth is the decline of unions. Indeed, at the macro-level, the decoupling of labor compensation from labor productivity is unambiguous (Figure 1).

Figure 1. Decoupling of labor compensation from labor productivity



Note: Decoupling of labor compensation (total gross earnings, social security contributions, pension plans, life insurance and benefit plans) from labor productivity (per worker and per hour). Labor compensation decrease in 2012 reflects the MoU wage cuts, in the public sector, as well as the freezing of bonuses and extra hours, in the private sector. 2013 is also partially influenced by the reversal of the wage cuts (declared unconstitutional) and historically high unemployment (16.2%).
Source: OECD-Productivity and OECD-Earnings-Average annual wages databases.

5. Thus, it is paramount to dig into the theoretical and empirical contributions for the classical political economy problem: what is the relationship between labor pay (e.g. wages) and labor productivity? Using administrative firm-level data for Portugal, during the period 2010-2016, we present some evidence for this relationship and investigate potential drivers of the the link between labor productivity and average wages. We also aim to shed some light into the heterogeneous effects of these channels along the distributions of wages and productivity.

6. The remainder of paper is organised in the following manner. Section 2 briefly reviews the theoretical and empirical literature. In section 3 we describe the dataset used. The different methodologies used are presented, and their results are discussed, in section 4, before concluding with some policy implications.

2. Literature Review

2.1. Theory

7. How does the wage-setting process take place and how tight is the link between wages and productivity? According to the neoclassical school of thought, profit-maximizing firms will hire labor until the marginal product of labor equals the real wage (John Bates Clark, 1899). Also known as the Walrasian theory of labor market equilibrium, the thesis predicts that wages and productivity increase at the same

rate. However, it relies on unrealistic assumptions such as perfect competition, constant returns to scale, absence of any market frictions – implying there is no involuntary unemployment -, symmetric information, and homogeneous agents. Knowing that workers differ in many dimensions, Mincer (1974) developed a seminal model for wages where, on top of the mentioned market clearing wage, wage premia are estimated for various worker characteristics – e.g. sex, education, experience, on-the-job training etc. Yet, even with homogeneous workers, in the absence of asymmetric information and under perfectly predictable productivity, agents incur search costs, which makes it costly to switch to change jobs and provides employers with bargaining power: it won't be optimal for firms to hire at the full marginal productivity (Van Biesebroeck, 2014).

8. On the other hand, (neo-) institutional economics, which incorporates neoclassical developments, models wage-setting as a Nash-bargaining game between workers and firms (Pissarides, 1985). In these models, how the surplus is split is determined by the relative bargaining power of labor, depending on the payoffs of outside options. These, in turn, depend on labor market conditions (Oreopoulos et al., 2012), such as unemployment benefits, job vacancies, monopsony power etc. Indeed, Manning (2011) points out that, often, firms pay less than the marginal revenue product of labor and workers receive more than their disutility of work. What is more, the Mortensen-Pissarides framework predicts that productivity-wage gaps will widen as the bargaining power of labor (e.g. unions) diminishes.[2]

9. Opposing to the conventional theory, the efficiency-wage theory advocates that higher wages incentivise workers to boost productivity. This theory (Shapiro and Stiglitz, 1984) rejects the premise that wages are aligned with marginal productivity even under perfect competition. Instead, they argue that it is rational for a firm to pay above market wages in the presence of labor market institutions such as unemployment benefits or firing costs. If a worker is currently paid a wage that is expected to be higher than the wage received at a new employer, this is sufficient incentive to induce greater effort – leading to productivity upsurges (Meager, 2011).

2.2. Empirical

10. Campbell (1993) developed an efficiency-wage model, with wage and quit equations, finding results that are generally favorable to this theory. Millea (2002) separates the relationship between productivity and wages into bidirectional mechanisms: productivity to wages (conventional) and wages to productivity (efficiency-wage). The author concludes that the dominating effect depends on institutional differences: unionisation increases the conventional mechanism while countries with lower replacement rates and less Active Labor Market Policies (ALMP) exhibit stronger evidence for efficiency wages. These findings are broadly consistent with efficiency-wage models to the extent that greater and lasting unemployment benefits increase the outside options' payoffs. Similarly, Strauss and Wohar (2004) perform bidirectional Granger causality tests on more than 450 U.S. manufacturing plants, over the period 1956-1996, finding a less than unity increase in real wages from productivity improvements and concluding that labor shares of these industries experienced a permanent decline.

11. There is a growing literature addressing the decoupling of wages from productivity (OECD, 2018; Sharpe et al., 2017; Bivens and Mishel, 2015; Pessoa and Van Reenen, 2012). Most of the literature puts forward several sources for the decoupling, many of which overlap with those mentioned by the wage stagnation literature: technological changes biased towards capital substitution of labor (Schwellnus et al., 2018), larger profit mark-ups and product market rents from weaker competition (Autor et al., 2017, Barkai 2017), diminished labor bargaining power and dual labor markets (Guschanski and Onaran, 2017; Peters, 2008 Levy and Temin, 2007), structural changes such as globalisation – global value chains and labor

[2] Using Panel-VAR estimations for 31 OECD countries during 1960-2009, Elgin and Kuzubas (2013) confirms the robust positive relationship between unemployment and wage-productivity gap, and a negative response from unionisation.

offshoring – (Autor et al., 2013) and financialisation (Cournède et al., 2015; Stockhammer, 2013), capital accumulation (Piketty 2014, Piketty and Zucman 2014) and income inequality (Atkinson et al. 2011).

12. Analyzing rising wage inequality together with real wage stagnation, Machin (2016) shows how both have gone hand-in-hand due to productivity-wage decoupling, and that median wage stagnation is linked to the declining influence of trade unions. Summers and Stansbury (2017) document the rise in U.S. productivity coupled with the stagnation of real median wages, starting in 1973. The authors highlight two main mechanisms for the decoupling: a rising gap between mean and median compensation (individual inequality), and falling labor shares (functional inequality). They argue that productivity growth is not enough to raise living standards and emphasize institutional and structural explanations. Pessoa et al. (2012) decomposed decoupling into wage inequality (faster average growth than median wage growth), the gap between wages and compensation (also including employer-provided benefits) and deflator differences. Similarly, Sharpe et al. (2016) decompose the productivity-wage gap into: inequality, income definitions between household surveys and National Accounts, deflators and changes in labor shares. Investigating 11 OECD economies over the years between 1986-2013, they conclude that, while there is no common cause for decoupling, most countries experienced inequality upturns and falling labor shares.

13. In a very recent EC discussion paper, Pasimeni (2018) shows that the decoupling is also significant in Europe. Using 34 advanced economies over the past half century, the author demonstrates that the deceleration of labor compensation is not merely a result of productivity slowdown or cyclical fluctuations but a product of structural conditions in labor markets such as reduced bargaining power of workers. Neoclassical theory regularly points to technological changes as the main determinant of income and functional distributions, whilst wage stagnation is a product of the productivity slowdown. On the other hand, heterodox economists typically regard these dynamics as the result of multiple institutional changes (e.g. Onaran et al., 2013). Accordingly, in a panel analysis of 71 countries from 1970 to 2007, Stockhammer (2013) finds evidence that, while technological change and globalisation (in production and trade) had some negative effects, financialisation had stronger negative impacts on the wage share, in both developed and developing countries. Furthermore, welfare state retrenchment and the decline in unionisation were also important determinants of falling wage shares in advanced economies.

14. It is also well stablished that declining labor shares – a global phenomenon since 1980 (Karabarbounis and Neiman, 2014) – are a reflection of the decoupling of wages from productivity. Looking at 15 advanced economies, between 1963 and 1996, Carter (2014) also argues against the Bowley's Law (i.e. the assumption of neoclassical theory of a constant wage share) by presenting evidence of a structural break (1979) in the functional distribution, when real wages are inelastic with regard to productivity and wage shares are on a generalised downward path. IMF (2017) find that increased participation in global value chains reduced labor shares for low-income countries but the effect is not significant for high-income ones. On the other hand, IMF (2018) find significant, large and robust negative effects of job protection deregulation on the labor share of 26 advanced economies, over the period 1970-2015.

15. In addition, Autor et al. (2017) show that labor shares declined particularly in U.S. industries with higher market concentration. In turn, the increase of anti-competitive product market regulations – e.g. lower anti-trust enforcement or non-compete clauses – raises rents (Furman and Orszag, 2015) and shrinks labor shares (Schwellnus et al., 2018). However, rents may have the opposite effect if they are shared with the workforce through wages. Blanchard and Giavazzi (2003) argue that labor market institutions, like collective bargaining and minimum wages, have a direct effect on how these rents are distributed between workers and capital-owners. The authors also stress that labor market reforms without product market reforms redistribute these rents from labor to capital, without lowering their total size. Without higher product market competition, labor market flexibility "does not enhance investment or productivity, but hurts workers" (OECD, 2018), widens income distributions (Dabla-Norris et al., 2015; Lemieux, 2008) and decreases labor shares (Stockhammer, 2013, Calderon and Chong, 2009).

16. Aiming at understanding the global slowdown in productivity growth, the OECD and others have presented several studiesover the last years. The literature points to: weak aggregate demand and historically low investment in physical capital (Remes et al., 2017; OECD, 2018), measurement issues – arising from the tertiarisation and digitalisation of economies – (Murray, 2017; Byrne et al., 2016), international profit shifting[3], slowdown in technological progress[4], global productivity frontier firms largely outpacing laggards, breakdown of the diffusion mechanism, declining business dynamism (Gouveia and Osterhold, 2018)[5] and lower product market competition. Chad Syverson (2010) summarises a myriad of papers on the determinants of productivity into two groups: those over which producers can have control (managerial practice, quality of labor and capital inputs, ICT and R&D, learning-by-doing, product innovation and firm structure) and factors that are external (competition, deregulation or proper regulation, flexible input markets and productivity spill overs).

17. Using cross-country firm level data for 24 OECD economies during 2001-2013, Andrews, Criscuolo and Gal (2016) argue that the aggregate labor productivity slowdown results from two micro-level mechanisms: a widening gap between the performance of frontier firms and laggards, and a deterioration of the process of creative destruction (fewer exits of weak firms and less entries). Focusing on TFP, the authors still find significantly higher growth at the frontier after controlling for mark-ups and capital deepening. They explain these phenomena with substantial market concentration at the frontier, winner-takes-it-all dynamics from digitalisation, increased importance of tacit knowledge and lack of product market reforms.

18. Using Portugal's firm data for a period of substantial structural reforms (2006-2014), Gouveia et al. (2017) find that, in general, reforms provide productivity improvements, despite initial costs in the short-term. While there are areas delivering productivity enhancements in both the short- and long-run (e.g. goods market, financial market, insolvencies), labor market reforms are found to have negative impacts for all firms but the 8% lowest TFP firms (who benefit only in the long-run). Exploring the same dataset, for the years 2010-2016, Branco, Domingues and Martins (2018) find positive and significant correlations between TFP and financial health, wage premium, innovation and exporter status, while non-linear effects are found for firm's age, capital intensity and training. Using matched employer-employee data for Portugal, Queiró (2016) demonstrates the crucial importance of the manager's education: it increases the firm's life cycle growth, those with college educated managers employ 12 times more than the average entrant, more educated managers use incentive pay schemes and incorporate more new technologies. Notably, the author estimates that if Portugal had the distribution of manager's education of the U.S. it would experience a 33% rise in aggregate productivity, accounting for half of the GDP per capita gap between both countries.

3. Data

19. The dataset used in our analysis comprises a myriad of firm-level characteristics, income statements, balance sheets, wages and some information on worker's contracts, of companies in Portugal. *Informação Empresarial Simplificada* (IES) is an extensive and unique document for the fulfillment of all the annual compulsory fiscal and accounting responsabilities of all private and public firms operating in

[3] Zucman, Torslov and Wier (2018) show that, between 1985 and 2018, the global average statutory corporate tax halved due to profit shifting. Close to 40% of multinational's profits migrated to tax havens in 2015.

[4] Robert Gordon (2016) argues that the ICT-driven productivity boom, occurred in the beginning of the century, was a deviation from normal state of affairs. In the author's rather pessimistic view, the period where the effects of the second industrial revolution (electricity, combustion engine, telephone etc.) were felt (1920-1970) is unlikely to be seen again.

[5] The authors estimate that circa 8% of firms in Portugal are non-viable/zombie firms (i.e. interest expenses greater than EBIT for 3 consecutive years) preventing efficient reallocation of about 20% of total capital and 10% of total labour. Using a less stringent definition, Alexandre et al. (2018) estimates that 26% of firms in Portugal are zombies.

Portuguese territory. Although it is mainly self-reported, only a certified accounting professional can fill in the information. Our version of IES was compiled by the *Banco de Portugal* (BdP) and subjected to quality checks, covering the period of 2010-2016. We chose this period to avoid issues arising from the change in accounting standards, namely the definition of tangible and intangible assets, that occurred in 2009-2010, and because it sufficiently covers the recession and the following recovery years. The classification used for economic activities was NACE Revision 3, where we consider sectors as the one letter sections and industries as the two-digit divisions, englobing total economy.

20. The initial dataset contained 2,783,238 firm-year pairs, encompassing the universe of operating firms with organised accounting in Portugal, during those seven years. To insure robustness and exclude misreported values, several data cleaning adjustments were done which substantially decreased the number of observations. We begin to delete firms with negative or nil values for: turnover, gross value added (GVA), total fixed and intangible assets as well as liabilities, workers and paid workers, labor costs and wages.[6] Finally, after examination of the labor productivity (both per hour and per worker) by sectors, one could see major outliers in the data, and, thus, the 0.5% and 99.5% tails of both distributions were removed. The final dataset is an unbalanced panel containing 1,144,661 observations and is representative of the population of companies in Portuguese territory.

21. Following most of the literature, our main indicator for labor productivity is GVA per worker. We followed *Banco de Portugal* (2014) definition of GVA as the sum of turnover and operating subsidies (output) minus utilities and external services, and the cost of inputs (intermediate consumption). Total Factor Productivity (TFP) was estimated through Levinsohn and Petrin (2003) semiparametric methodology, which uses intermediate inputs as proxy for unobservable productivity shocks.[7] The output variable is the firm's turnover, the proxy is external services and utilities, while labor costs (labor) and the sum of fixed and intangible assets (capital) form the production function. For robustness, following Berlingieri et al. (2017), we also include a non-parametric measure of TFP similar to the Solow residual, which relies on important assumptions. Finally, the wage variable is the total annual firm's remuneration divided by the number of workers.

22. Turning to the determinants of productivity, taking the Eurostat definition, Size is a categorical variable ranging from 1 (micro) to 4 (large) according to the number of workers.[8] Training is expenses of on-the-job formation over total labor costs, while Age is the rounded number of years since the firm's date of birth. To analyze the effects of what the recent literature is referring to as labor market slack, Irregular Contracts variable is the sum of workers with temporary, service providers/independent workers or part-time contracts relative to the workforce. Following Martins et al. (2018), we consider the *Banco de Portugal* definition for Exporter Status, where this dummy variable takes the value of one if at least one condition is verified: firm exports 50% of its turnover or 10% of its turnover is exported with that value being greater than €150,000.[9] Likewise, a rough proxy for Innovation Status is assigned if the firm's intangible assets exceed the respective annual industry's median or if it has more personnel in R&D than its industry's annual median. It is important to consider the level of Capital Intensity computed by total fixed assets value over labor costs and the corresponding square to account for possible non-linear relations.

23. To assess the importance of high electricity prices (see Annex A), the weight of Electricity Costs for the firm is expressed relative to EBITA. Portugal's net external debt went from less than 30% of GDP to almost 95% of GDP, between 2000 and 2016. To capture companies' financial difficulties, we take the

[6] Additionally, observations with negative values for ICT per worker and interest paid were also dropped.

[7] See Ana Martins, et al. (2018) for a comprehensive review and explanation of the literature on TFP estimation issues and strategies.

[8] Micro (1) = less than 10 workers; Small (2) = 10 to 49; Medium (3) = 50 to 249; Large (4) = more than 250 workers.

[9] Exports over GDP grew 10pp points, from 30% to more than 40%, surpassing imports over GDP, between 2010 and 2016. More openness should have effects on the relationship between productivity and wages.

ratio of total liabilities to total equity (Leverage), the same for Non-Performing Loans (NPL) and Net Interest received over EBITA. Executives of stock market companies in Portugal receive, on average, 23 times more remuneration than their average worker, reaching a ratio of more than 150 in some cases.[10] Given the solidification of the global shareholder economy, where stock value is the primary goal and administrator's remuneration increases with stock options (Lazonick, 2011; Stockhammer, 2010; Fligstein and Shin, 2007), we take the board/administrator's remuneration relative to the total wage bill (Board compensation).

24. Finally, we consider two policy indicators: the annual Minimum Wage from the OECD-LFS database and the Labor Market deregulation index. The latter is retrieved from Fraser Institute (Gwartney et al, 2012) because the most common indicator (OECD Employment Protection Legislation) is not available from 2013 onwards. Nevertheless, the correlation between the two is higher than 0.99, in absolute value, and the chosen index closely follows the inverse of the EPL trend (as we will later see in Figure 9).

4. Methodology and Results

25. Taking advantage of this representative firm-level data, this paper aims to assess to what extent productivity and waes are linked and to shed some light on what factors determine the tightness of this link, i.e. the productivity-wage nexus.

4.1. Great Divergences and links at the sectoral-level

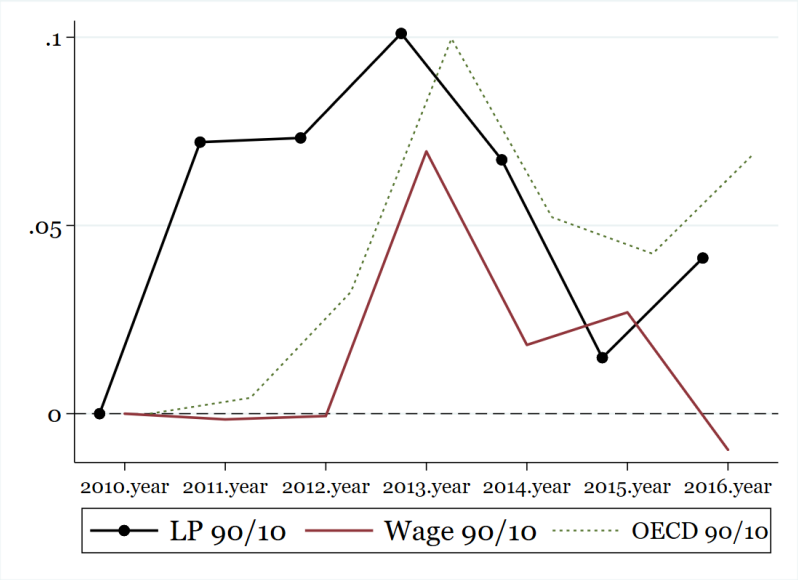
26. We begin our investigation by replicating parts of a recent paper by Berlingieri, Blanchenay and Criscuolo (2017), since Portugal was not included. We apply the same methodology to assess: (a) the evolution of the sectoral dispersion of both productivity and wage measures; (b) and investigate the relationship between these dimensions. The former is achieved by plotting the coefficients of the year dummies from equation (1):

$$(log\, Y_{Percentile\ high} - log\, Y_{Percentile\ low})_{st} = \alpha + \beta_t year_t + \delta_s + \varepsilon_{st} \quad (1)$$

Where the left-hand side is a measure of sectoral dispersion of the variable of interest (e.g. log 90th/10th percentiles of wages or of productivity), **βt** capture the average dispersion in each year controlling for unobservable time-invariant variables with a δs vector of dummies for each sector (fixed effects).

[10] See https://eco.sapo.pt/2018/09/30/ceo-portugueses-ganham-23-vezes-mais-que-trabalhadores-e-la-fora/.

Figure 2. Evolution of sectoral divergence of productivity and wages

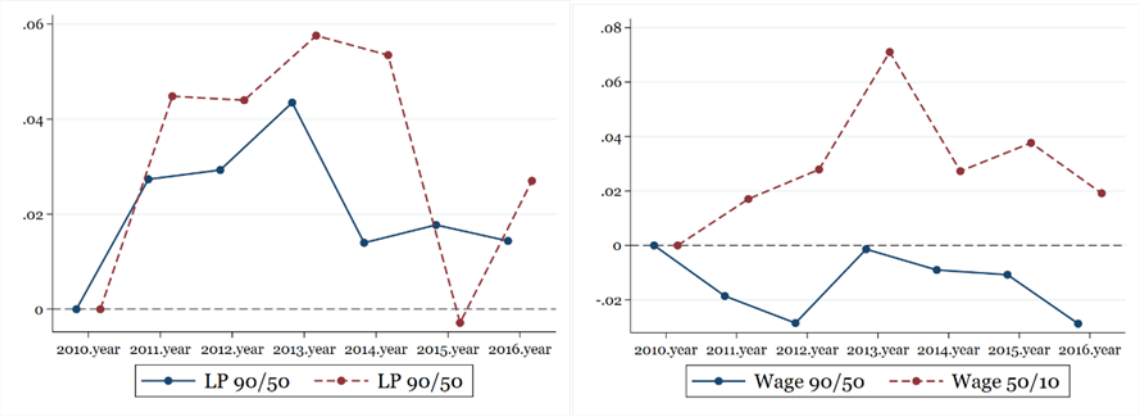


Note: Evolution of logged (90th/10th) of labor productivity (dash line), wage dispersion (solid), plus overall earnings inequality for Portugal based on OECD-IDD database. Graph plots the betas for each of the above.

27. In line with the average of OECD countries, Portugal has experienced upsurges in dispersions, particularly until 2013, both in productivity and wages – with the latter fairly following the trend of overall earnings inequality. This shows that heterogeneity in productivity and wages also increased among firms within the same sector. According to Figure 2, by 2013, within-sector labor productivity dispersion was 10% higher than in 2010, whereas wage dispersion was 7% higher. By 2016, overall wage dispersion returned to the levels of 2010, while that of productivity remained 4% above. Thus, dispersions display a considerable pro-cyclical behavior, with peaks in 2013, the year of record high unemployment rates.

28. Estimating equation (1) for the top (90th/50th) and bottom (50th/10th) halves of the distributions, we confirm that the increase in overall sectoral dispersion of wages is driven by the bottom, while in the case of productivity both halves contributed to the Great Divergence. Considering the three wage curves (Figure 3), there is evidence that workers in low-paying firms were much more penalised during the crisis, but recovered in the last year, outpacing high-paying and median firms. On the other hand, looking at the three curves of labor productivity (evolutions of the 90th, 50th and 10th percentiles), one can see that the top firms performed better than median and bottom firms throughout the whole period. Low productivity firms only outpaced the median in 2015, whereas median firms kept up with top performing firms since 2014, enhancing their relative productivity in the last year. Although there's evidence that productivity in high-performing firms has significantly diverged from the remaining companies the same cannot be said for wages. Thus, there is evidence that productivity gains of top firms where not sufficiently shared with their workforce – suggesting an increase of rent hoarding in the most productive firms. The absence of upper-half wage dispersion increase contrasts with documented widening of wage inequality, from 1984 to 2009, at the individual level (Centeno and Novo, 2014).

Figure 3. Evolution of sectoral divergence of productivity and wages



Note: Labor productivity (LHS) and wage dispersion (RHS) divided in to top (solid; 90th /50th) and bottom (dashed; 50th/10th) halves. Each line plots the coefficients from the four estimations of equation 1.

29. A similar specification is employed for (b), only now we are interested in identifying the relationship between productivity and wage sectoral dispersions over time, controlling for overall time shocks, as those from the crisis, and sector-specific fixed-effects. Thus, we run the following equation (2):

$$log(Y\ dispersion)_{jt} = \alpha + \beta\ log(X\ dispersion)_{jt} + year_t + \delta_s + \varepsilon_{st} \quad (2)$$

30. In line with the mentioned paper, results from Table 1 demonstrate a positive and significant link between labor productivity and wage dispersions at the sectoral level. More specifically, on average, an increase of one standard deviation in logged dispersion of productivity per worker is correlated with a 10.7% increase in logged wage dispersion, among companies within the same sector.[11] Likewise, in column (2) an increase of one standard deviation in TFP is associated with an 8.1% increase in wage dispersion, significant at the 5% level. Nevertheless, the explanatory power is much lower than those found in the paper.

[11] To interpret as in Berlingieri (2017). For example, standard deviation of log LP (90th/10th) is roughly 0.7, multiplying by the estimated coefficient 0.153 equals 0.107.

Table 1. Great Divergences between productivity and wages

Table 1 - Great Divergences(s) - log Wage (p90/p10)			
	(1)	(2)	(3)
log LP (p90/p10)	0.153***		
	(0.0441)		
log TFP (p90/p10)		0.0571**	
		(0.0241)	
log TFP_ols (p90/p10)			0.109***
			(0.0199)
Observations	134	126	135
Number of sectors	20	18	20
Sector and Year fixed effects	YES	YES	YES
R^2 adjusted	0.245	0.161	0.146

31. By conducting the same regressions for the top (90th/50th percentile ratio) and bottom (50th/10th) of the distributions, one can explore whether the link is homogeneous across the distribution. Output 1 (Annex A) shows no evidence of a positive relationship between any productivity top-half polarisation and wage top-half divergence. This may be an indication that top-performing companies are not sharing rents and profits with their workforce, channeling productivity gains to shareholders and/or to the board's compensation. In fact, only labor productivity's top dispersion is significant but negative. This suggest that: (i) productivity improvements at the top – relative to the median – do not translate into appropriately higher wages for the former; and/or that (ii) sectors with median performing firms – deteriorating relative to top firms – do not decrease wages accordingly, due to reasonable downward wage stickiness. On the other hand, results for the (50th/10th) are positive, significant and very similar to the overall (90th/10th) ones. It follows that a relative change of productivity for median firms is associated with a change of wages. Thus, (i) might be a better explanation for the abovementioned and results from the previous table seem to be driven by dynamics at the bottom half of the distributions.

4.2. How much Productivity Gains passed on to Wages?

32. Having investigated the connections between productivity and wage in terms of their sectoral dispersions we now dive into the firm-level relationships. The neoclassical literature, conditional on the abovementioned assumptions, posits that firms will raise average wages in line with productivity gains. Focusing on the productivity-wage pass-through, that is "rent sharing", at the firm level, we are conscious that the link might be weaker than the aggregate one insofar macro productivity and wage upsurges also derive from reallocation across firms. Thus, when inspecting the nexus within firms, one can expect lower coefficients, specifically below one.

33. One important caveat of the database is that it does not contain any information about the wage structure or the skills of workers. So, it is impossible to test if higher average wages arise merely from higher board compensation nor is it possible to control for the educational level of workers. Moreover, one should keep in mind that regression analysis only allows for causal inference given a randomised experiment, a quasi-experimental research design or matching techniques for observational data, providing the possibility to construct a convincing counterfactual (A. Nichols, 2008). Notwithstanding, regression coefficients have an implicit direction assumption and we can test the correlations between productivity and average wage at the firm level (Pasimeni, 2018). We should also have in mind that univariate regressions with these variables might suffer from omitted variable bias – one source of endogeneity. To mitigate this issue, we run regressions with year, sector and firm fixed effects (3 and 7)

and repeat the analysis with lagged regressors to avoid the risk of simultaneity (4-8) – another source of endogeneity.

34. Our baseline regression assesses the overall link through pooled OLS, which can be seen as the long-run relation between productivity and wages (1 and 5). Next, we include the average productivity of the firm's industry (two-digit NACE) to account for worker's outside options and the competitor's productivity trend, allowing one to understand whether more aggregate productivity shocks are more strongly passed on to wages (2 and 6). To focus on the pass-through of productivity gains to wages that occur within firms (3 and 7), rather than between, we include firm fixed effects (θ_i), while controlling for across the board annual shocks ($year_t$) and unobservable sector heterogeneity (δ_s). All regressions test for relationships between the log level of firm's average wage and the log level of the firm's labor productivity, estimating the elasticity between both. Finally, we also assess the relationship in terms of wage and productivity growth, which already accounts for unobservable firm heterogeneity and can be seen as the short-run elasticity between productivity and wages.[12]

$$log(Average\ Wage)_{it} = \alpha + \beta\ log(Labor\ Productivity)_{it} + year_t + \delta_s + \theta_i + \varepsilon_{it} \quad (3)$$

$$growth(Average\ Wage)_{it} = \alpha + \beta\ growth(Labor\ Productivity)_{it} + \varepsilon_{it} \quad (4)$$

35. We define growth rate variables as the firm's consecutive change divided by the product of the original level and duration. This way, we account for annual gaps in our unbalanced panel set (i.e. when n>1). In addition, we remove the outliers above the 99th and below the 1st percentiles both for average wages and GVA per worker as well as per hour. Consequently, more than 340,000 observations are lost in those regressions and the mean growth of firm's productivity is almost 8pp higher than that of wages with a much higher standard deviation.

$$\text{growth rate of X} = \frac{X_t - X_{t-n}}{[X_{t-n} * (t - (t-n))]} * 100 \quad (5)$$

[12] Note that results from these growth form regressions do not change if we measure labor productivity per hour or when year and sector fixed effects are included. In addition, conducting the same analysis with both GVA and average wages deflacted by sector Producer Price Index does not alter the results.

Table 2. Relationship between wages and present and past productivities

Table 2	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	log (wage)			growth (wage)	log (wage)			growth (wage)
log(LP)[t]	0.325***	0.314***	0.174***					
log(indus. avg. LP)[t]		0.0914***	-0.0746***					
LP growth[t]				0.147***				
log(LP)[t-1]					0.283***	0.263***	0.0122***	
log(indus. avg. LP)[t-1]						0.156***	0.0510***	
LP growth[t-1]								-0.00401***
Observations	1144661	1144661	1144661	802778	852934	852934	852934	596994
Number of firms	291727	291727	291727	218731	226597	226597	226597	177573
Firm, Year and Sector Fixed Effects	NO	NO	YES	NO	NO	NO	YES	NO
R^2 within			0.146				0.0127	
R^2 overall	0.341	0.344	0.327	0.120	0.264	0.274	0.0994	0.000842
R^2 between			0.332				0.119	

Robust standard errors are clustered at the firm level: * p < 10%, ** p < 5%, *** p < 1%.

36. Results presented in Table 2 confirm the positive correlation between productivity and wage in levels and growth rates, which are significant at the 1% level. Looking at the first two models, we can see that the estimated long-run overall relationship between productivity and wage is lower than one. The average firm in the market only translated close to one third of productivity gains into higher average wages. Furthermore, this pass-through seemed to be associated with the productivity level of the firm's industry. However, from model 3, one can conclude that less than 20% of current productivity gains within firms pass on to their wages. Indeed, the majority of the productivity-wage nexus is explained by variations between rather than within firms. Focusing on the nexus within firms, while controlling for annual overall effects (year fixed effects) and sector idiosyncrasies (sector fixed effects), the industry's average productivity appears to be negatively correlated with the firm's average wage. A possible explanation for this result is that, on average, the firms that continued to operate throughout the recession period (2011-2013) paid lower wages than their industry's average. From regression (4), one can induce that the short-run pass-through from productivity gains to wages is lower, where one percentage point acceleration in present productivity growth is associated with a less than 0.2 percentage point acceleration in wage growth, confirming the results from the previous model.[13]

37. Looking at the second panel (regressions 5-8), one finds similar but lower effects on present wages from past productivity gains, particularly when focusing on within firm variations (model 7). These results suggest that only observed (past and not present) worker's outside options (i.e. higher industry's productivity) contribute to higher wages. Interestingly, there seems to be evidence that, even within operating firms, higher industry productivity in the past motivates more wage increases in the present than within firm past productivity gains. Accordingly, past productivity growths are negatively associated with present wage growth.[14]

38. The relationship between productivity growth and wage growth can be visualised in Figure 4 where we display sectoral density functions of the ratio (L.P. growth over wage growth), for every firm-year pair. We take the natural logarithm of the ratio for presentation purposes, knowing that the transformation normalises distributions. Note that if a firm raises wages at the exact same pace of productivity improvements – as neoclassical theory predicts –, the logged ratio will equal zero. We present the

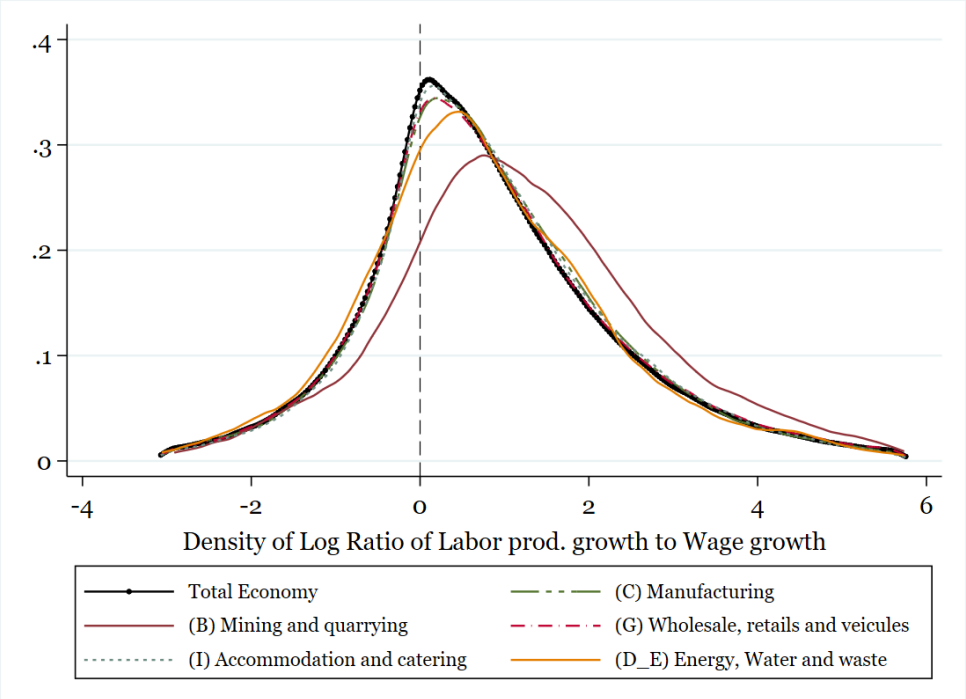
[13] Labor productivity and average wage growths' outliers below the 1st and above the 99th percentiles were removed in both series to avoid estimation biases, e.g. arising from merges.

[14] All these results do not change if we measure labor productivity by hours worked instead of by workers and are available upon request.

distribution of this ratio for the total economy as well as for some illustrative sectors. Namely, we chose the largest sectors in terms of employment (G and C), the fastest employment share growth sector (I), and the two sectors related to natural resources and with the highest ratios (B and the aggregation of D and E). In line with previous findings, all distributions are shifted to the right of the vertical red line, with modes larger than zero.[15] In line with the results from models (1) and (2), this suggests that more than two thirds (>70%) of firms in each year did not raise average wages in line with labor productivity.[16]

39. As we will explain later, this means that a large proportion of firms saw their labor shares change annually from 2010 to 2016. It could be the case that labor shares decreased in firms experiencing a positive productivity shock, i.e. growth of productivity was higher than the growth of average wages, whereas labor shares increased in firms simply recording negative productivity shocks. Indeed, from those that recorded falling labor shares (the majority) there were more firms with increases in productivity (53%) than those with negative variations of their productivity levels. Yet, surprisingly, among the minority of firms which saw their labor share increase (reduced decoupling), more firms did so while experiencing positive productivity shocks (54%) and not the opposite.

Figure 4. Distribution of productivity to wage growth ratios by sectors



Note: Density functions of the (logged) ratio of productivity growth to wage growth for every firm-year pair. The vertical dashed line represents the situation where wage growth matches that of GVA per worker. Note that a mode of 0.5 indicates that most firms should have raised wages by 65% more if the aim was to match growths. Logged ratio of growth's outliers above the 99th and below the 1st percentiles were removed.

40. Having estimated the average nexus, we explore the presence of heterogeneous correlations along the distribution. Increasing wages in a top-performing firm may have different effects on productivity compared to the effects of having the same wage increase in a low-productivity company. Conversely,

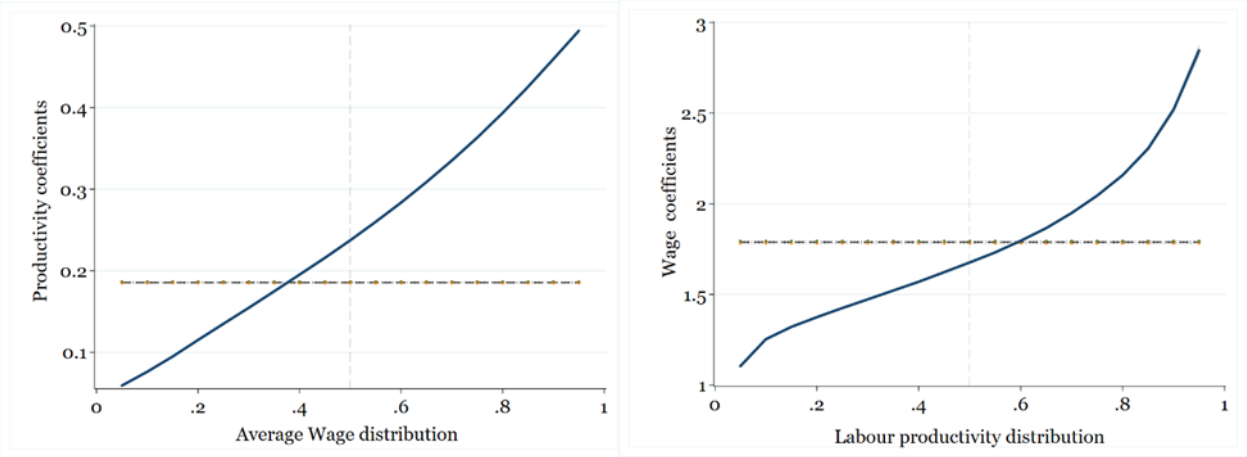
[15] These results do not change if take industry Producer Price Index deflators to estimate real labour productivity and real wages. In fact, in real terms, density functions are slightly more skwed to the right than in nominal terms.

[16] After losing more than 290,000 observations in the calculation of the growth variables and removing 1% top and bottom tail's outliers, we end up with 527,272 logged ratio observations, 378,169 (71.7%) of which are greater than zero.

productivity growth in a low-paying firm can increase wages by more or less than in a high-paying one. To shed some light on this question, we resort to quantile regressions (Koenker and Basset, 1978) which allow us to assess the relationship between the variables of interest along different points of the conditional distribution, instead of just at the conditional mean as OLS. Quantile regressions relax some of the OLS assumptions and, thus, are more robust to non-normal errors or outliers (Baum, 2013), by minimizing a different loss function, which gives more weight to observations around a quantile τ, through a check function ρ:

$$Q_\tau(\mathrm{Y}_i|\mathrm{X}_i) = \arg\min_{q(X)} \; E\left[\rho_\tau(\mathrm{Y}_i - q(\mathrm{X}_i))\right] \tag{6}$$

Figure 5. Heterogeneous productivity-wage nexus across the distributions



Note: Coefficients of quantile regressions of average wages (dependent variable) on GVA per worker (left) and of productivity (dependent variable) on wages (right). The horizontal line represents the respective OLS estimates.

41. We run two hundred univariate quantile regressions, one for each 0.05 quantile increment until the last percentile, first for productivity and then for wages. These coefficients are plotted in Figure 5 along with the two simple OLS estimates. Firstly, one can see that there is substantial heterogeneity across both distributions, which is invisible through OLS. Both display a pronounced upslope monotonic relation along each distribution. That is, productivity gains in high-performing companies are associated with larger wage upgrades and a wage increase is correlated with greater productivity gains in high-paying firms than in low-wage ones. The wage increase, from productivity enhancements, in a median-paying firm is larger than for a company paying average wages. Whereas, the positive productivity shock arising from a wage increase is greater for firms with average, than with median, productivity.

4.3. Decoupling of Wages from Productivity

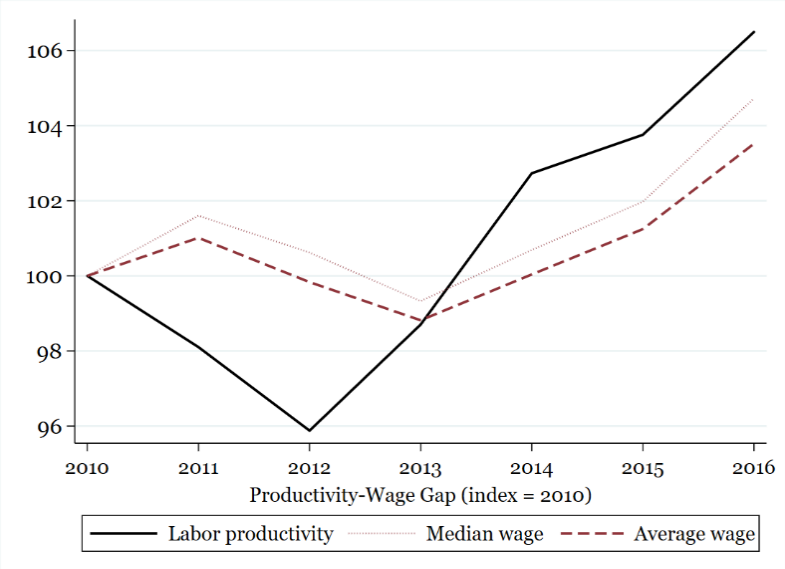
4.3.1. Labor shares and Unit Labor Costs

42. All the results above demonstrate two dynamics: the increase in dispersions of productivity and wages – *Great Divergences* (Berlingieri et al., 2017) –, and the decoupling of wages from productivity (Schwellnus et al., 2018), presented in the Figure below.

43. Turning to Figure 6, the industry's mean labor productivity exhibits an expected pro-cyclical behavior, closely following macro-level real GDP growth. Compared to 2010, productivity decreased almost 2% in the first year of the recession (compared to annual -1.8% real GDP growth) and dropped by

4% in the worst period (roughly the same as annual real output downturn in 2012), rapidly recovering to 6% higher values than in 2010. In contrast, wages displayed significantly less volatility due to wage-stickiness (Keynes, 1936), but also downward nominal wage rigidity, which is high by international standards (Dickens et al., 2006). In fact, according to the Portuguese labor code, employers are prohibited to pursue nominal wage cuts, with very few exceptions related to collective bargaining (Article 129th, d).

Figure 6. Decoupling of productivity and wages at the micro-level



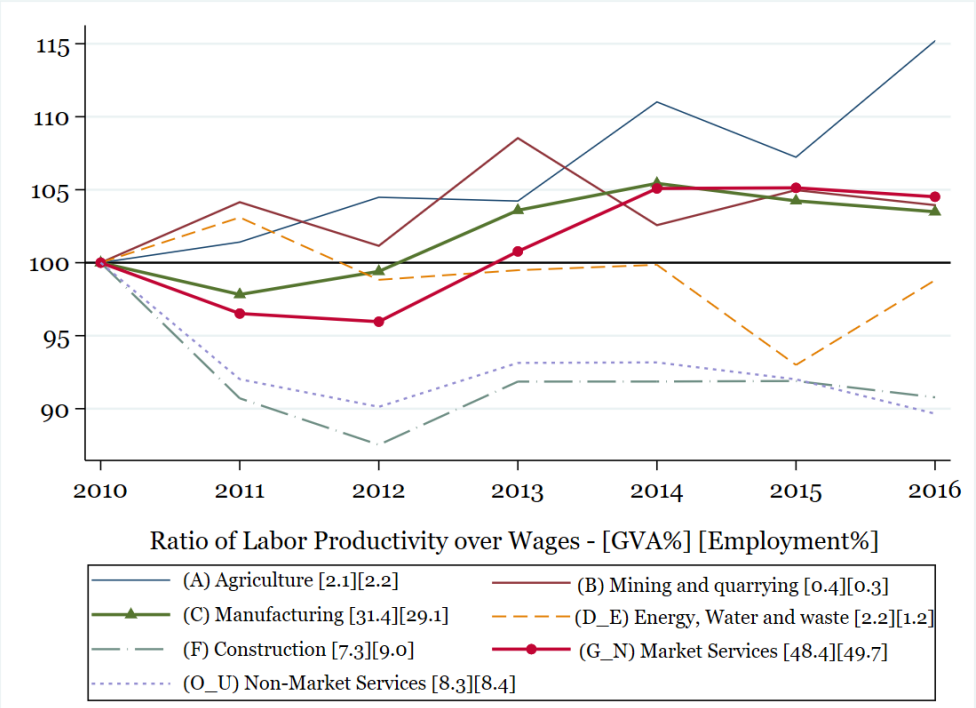
44. Note: Each series is derived by estimating the industry mean GVA per worker, average wage and the industry's median value for the latter, per year. Next indexes, based on 2010, are calculated within each industry and then annually averaged.

45. This might put some pressure on the firm's labor costs during downturns, complicating the adjustment to avoid bankruptcy. The closure of these less productive firms is likely to be an explanation for the 2011's increase in wages depicted in the graph, since the total number of firms decreased by around 20,000 (Figure A.3). Furthermore, one should keep in mind the importance of these rigidities, particularly in recessions, for they act as a buffer for domestic demand, output volatility and risks of deflation, and speed up economic recovery (European Commission, 2018). Interestingly, as real output growth returned to positive values (2014) a productivity-wage gap appeared, even with nominal wage upturns. Lastly, we should bear in mind that not only is the decoupling more pronounced at the macro-level (Figure 1) but also that it would be much larger for a greater timespan. Indeed, from all EMU countries, Portugal recorded the largest cumulative decrease in Unit Labor Costs (ULC), depicted in Figure A.1, and was the only economy experiencing a decline in real compensation per employee, from 2000 to 2016 (EC, 2018).[17]

46. Following Zhang and Liu (2013), in order to capture this phenomenon in one indicator, we take the ratio of labor productivity to average wage for each firm-year pair. In Figure 7 we display the evolution of the ratio for each macro-sector of the economy. By doing so, the sectoral heterogeneity in terms of decoupling becomes evident. The gap has widened in all sectors, except in Non-Market Services (O_U) and Construction (F), while in Energy, Water and Waste (D_E) it stabilised in 2016.

[17] In the EC note for the Eurogroup, the largest ULC decrease is attributed to Ireland but only because of revisions in calculation methods for the Irish real GDP (component of the ULC denominator) resulting in a 25% growth in 2015.

Figure 7. Decoupling of productivity and wages at the micro-level, by sectors



Note: Depicts the evolution of the ratio of GVA per worker over firm's average wage for each group of sectors, in-dexed at 2010. It also shows the GVA and employment shares of those sectors.

47. Even though the largest gap increase is found in Agriculture (A), as expected, Market Services (G_N) and Manufacturing (C) are the main sources of the overall productivity-wage gap, representing circa 50% and 30% of total GVA and employment, respectively. What is more, although these sectors show slight decreases until 2012, we can see that the Construction sector's severe decline of 15% (20% in GVA, according to Statistics Portugal) largely explains the abovementioned productivity downturn (Figure 6).

48. Before diving into some of the determinants of the decoupling, it is important to clarify its consequences and relation to Unit Labor Costs (ULC). As emphasised by Felipe (2005 and 2011), in practice, ULC can be interpreted as the labor share multiplied by a price deflator:

$$ULC = \frac{Wn}{(GVAn/P)/L} = \frac{Wn * L}{GVAn} * P \tag{7}$$

$$= \frac{Total\ Labour\ Comp.}{GVAn} = Labour\ Share * P$$

Where *Wn* is the average nominal wage/compensation rate, *L* the number of workers and *P* the price deflator. Furthermore, our measure for the decoupling can be rearranged as such:

$$Ratio = \frac{GVAn/L}{Total\ Wages/L} = \frac{1}{T.\ Wages/GVAn} = \frac{1}{Wage\ Share} \tag{8}$$

49. Thus, taking other forms of labor compensation (e.g. employer-provided benefits) and the deflator as constant, promoting ULC reduction is equivalent to decreasing the labor share. This parallelism is also visible when comparing Figure A.1 and Figure 9. In turn, lowering labor shares equates to widening the

gap between labor productivity and wages – i.e. an increase in our ratio. Despite the fact that, historically, there is no clear relationship between ULC and output growth (Kaldor's Paradox), the IMF and the EC constantly advocate for its reduction in the name of competitiveness (i.e. internal devaluation).[18] What is more, on top of the direct increase in functional inequality, reduced labor shares can have recessive effects on wage-led economies. Onaran and Obst (2016) demonstrate that an isolated decline in the wage share leads to lower growth in eleven EU-15 countries, including Portugal. Yet, if the fall in wage shares is simultaneous then there is an overall decline in EU-15 GDP. The authors, thus, conclude that Portugal, as well as the EU-15 as a whole, are wage-led economies.

4.3.2. Determinants of Decoupling

50. To investigate some of the quantifiable drivers of the decoupling of wages from productivity, at the firm level, – i.e. changes in ratio of productivity to wages – we run within firm estimations through equation (3):

$$log(Labour\ Productivity/\ Wage)_{int} = \alpha + X'\beta_{int} + \delta_{in} + \varepsilon_{it} \quad (9)$$

51. Where $X$is the vector of covariates used in each regression, δ_{in} captures industry fixed effects and ε_{it} is the error term. This specification is chosen so that we can later compare these results for the ratio with those for the numerator and denominator, along their distributions. Notwithstanding, we also report very similar results when using firm as well as year fixed effects in Output 3 in Annex A. While our main model is presented in column (4), we also show results for three reduced forms and include standard firm characteristics that affect productivity and wages (e.g. Martins et al., 2018) in model (5) for robustness. Several robustness checks for this complete model (5) can be found in Output 4 in Annex A. Coefficients can be interpreted as semi-elasticities, given that the ratio is in logs while regressors are in levels.[19]

[18] See, for example, Paul Krugman in: https://krugman.blogs.nytimes.com/2010/05/17/et-tu-wolfgang/ (Felipe, 2011).

[19] In contrast with the previous estimations, the following regressions might loose representativeness of the universe of firms operating in Portugal since, for example, not all companies invest in on-the-job training for their workers (see Summary Statistics in the annex, p. 31).

Table 3. Determinants of the decoupling between productivity and wages

Table 3	(1) log(LP/Wage)	(2) log(LP/Wage)	(3) log(LP/Wage)	(4) log(LP/Wage)	(5) log(LP/Wage)
Training	1.557***			1.293***	1.222***
Export status	0.0456**			0.0544***	0.0745***
Irregular contracts	0.0810***			0.0895***	0.0725***
Innovation status		-0.0274***		-0.0314***	-0.0283***
Electricity costs		-0.753***		-0.739***	-0.747***
Net interest received		0.0404***		0.0265***	0.0301**
L.M. deregulation			0.0112***	0.0204***	0.0186***
Minimum wage			0.0000441***	0.0000360***	0.0000415***
Board compensation			0.231***	0.145***	0.123***
Size					-0.0437***
Leveradge					-0.00000884*
Capital intensity					0.0148***
Capital intensity^2					-0.0000199***
NPL / Equity					-0.00000407***
Observations	152796	479444	714261	108176	99684
Number of industries	83	83	83	82	82
Industry fixed effects	YES	YES	YES	YES	YES
R^2 within	0.0109	0.0803	0.0266	0.0895	0.136
R^2 overall	0.0142	0.0758	0.0334	0.0857	0.151
R^2 between	0.00149	0.000877	0.00200	0.00681	0.244

Robust standard errors are clustered at the two-digit industry level: * p < 10%, ** p < 5%, *** p < 1%.

52. Surprisingly, results indicate that companies which invest more in on-the-job training relative to labor costs tend to have a weaker link between productivity and wages. Yet, this is consistent with the findings of Konings et al. (2015) to the extent that they find a substantially larger productivity than wage premium from work-related training. The same is true for companies with an export status as price competitiveness partially depends on the firm's ULC relative to trading partners. On the contrary, firms that have an innovative status are associated with lower ratios and, thus, tend to have stronger links between productivity and wages. Furthermore, on average, having a higher share of irregular contracts tends to decouple wages from productivity. Biesebroeck (2014) points out that the unwinding of labor regulations encourages a dual labor market where firms have the incentive to hire workers, many times younger and carrying higher human capital through theses atypical contacts to lower costs.

53. Berlingieri et al. (2017) found no significant effects from changes in EPL on the link between wage and productivity sectoral dispersions, once they accounted for country-sector year fixed effects. At the industry and firm level, we find evidence that the extensive labor market flexibility reforms, pushed throughout the adjustment program (2011-2014), contributed to the widening of the gap between productivity and wages, significant at the 1% level. Note that in column (4) the latter controls for the use ofirregular contracts to ensure that lower labor protection does not increase the gap only due to a lower share of permanent contracts in the firm's workforce. The negative impact of labor market deregulation on labor shares is robust to a myriad of different specifications, as one can see in Outputs 3 and 4 in Annex A.

54. Results for the impact of annual minimum wages on the productivity-wage nexus are mixed, depending on the specification, although coefficients are always very small. This could be due to the fact that minimum wages were frozen during the adjustment programme (2011-2014), with only two updates in

the following years. This finding is consistent with those of Berlingieri et al. (2017), concluding the same in terms of sectorial dispersions for OECD countries. As in their paper, results are positive if we do not account for year fixed effects and negative if we do.

55. Moreover, we find evidence that companies with higher board's compensation relative to the total wage bill are associated with wider decoupling of wages from productivity, significant at the 1% level. On average, a percentage point increase in relative remuneration of executives is associated with an increase in decoupling of around 15%. Note that this remuneration does not include other income sources, which are usually included in executive pay (e.g. interests and capital gains). That is, upsurges of this indicator should translate into higher within-firm wage inequality, since the workforce receives a smaller share of the total wage bill. Surprisingly, electricity costs over EBITA appear to be associated with lower productivity-wage gaps. Indeed, in almost all sectors with the lowest ratios these costs represent at least 20% of EBITA (overall average 15.5%), with the lowest ratio sector – Accommodation and catering (I) – having the highest rate of 35% (Annex A). On the other hand, companies with higher net interests received tend to have higher productivity relative to wages. Finally, capital intensity has a non-linear influence: it increases the ratio until a turning point where more capital per worker tends to decrease it. These findings are also robust to the exclusion of conventionally dropped sectors, where productivity estimation is less reliable – column (6) of Output 4 (see Annex A).

4.3.3. Determinants of Productivity and Wage Divergences

56. Naturally, changes in the ratio can result from changes in the numerator and/or denominator. In order to understand not only how each determinant affects decoupling but also how those effects vary for firms at different parts of the distributions, we perform Unconditional Quantile Regressions (UQR) with fixed effects at the industry-level at three quantiles: 10th, median (50th) and 90th.

57. Firpo, Fortin, and Lemieux (2009) developed UQR which allow estimating effects on quantiles defined pre-regression – i.e. not influenced by the chosen covariates (Killewald and Bearak 2014). In UQR one can adjust for selection bias including fixed effects without redefining the quantiles, through a methodology and STATA command developed by Borgen (2016). Naturally, the unit of clusters cannot be the firm as there would be no distribution to extract quantiles from. Therefore, we chose to focus on the first level of aggregation available: two-digits industries. Thus, we run UQR on productivity (numerator) and average wage (denominator), with industry fixed effects and standard errors clustered by industry, using the same set of covariates as before. This technique allows us to assess which of the decoupling's determinants also contribute to the divergence of the distributions of productivity and wages, by comparing the coefficients of the 10th unconditional industry's percentile with those of the 90th percentile (Figure 10).

58. In Annex A, we also show the results when including year fixed effects.[20] Those models also include average wages in the productivity regressions (Output 5) or productivity in the average wage regressions (Output 6), which increase their explanatory power, particularly in the former. In fact, the finding that increases in the firm's average wage have a larger effect on productivity, as compared to the opposite effect of productivity on wages (Efficiency-wage theory), is confirmed for every quantile, regardless of the controls used. Tables 4 and 5 show evidence of heterogeneous effects with some determinants driving the *Great divergences*, having higher absolute impacts on higher quantiles or opposite signs between bottom and top quantiles.

[20] Note that in those models the dependent variable is in level and not in logged levels and in Tables 4 and 5, which explains the substantial difference between coefficients.

Table 4. Determinants' effects on productivity's divergence (numerator)

Table 4	Unconditional Quantile Regressions by industry with fixed effects					
Labor Productivity	(4)			(5)		
log(LP)	Q(10)	Q(50)	Q(90)	Q(10)	Q(50)	Q(90)
Training	0.715***	0.678***	1.110***	0.675***	0.608***	0.941***
Export status	0.147***	0.301***	0.429***	0.104***	0.213***	0.344***
Irregular contracts	-0.331***	-0.0871***	-0.00685	-0.330***	-0.100***	-0.0412
Innovation status	0.0813***	0.149***	0.128***	0.0448***	0.0808***	0.0561***
Electricity costs	-0.686***	-1.049***	-0.963***	-0.775***	-1.086***	-0.977***
Net interest received	0.0602***	0.0236***	0.0166**	0.0684***	0.0247***	0.0187*
L.M. deregulation	0.000501	-0.00844	-0.00387	0.00263	-0.00268	-0.000310
Minimum wage	0.000106***	0.0000624***	0.0000387***	0.000109***	0.0000681***	0.0000502***
Board compensation	-0.182***	-0.127***	0.0759	-0.107***	0.0124	0.196**
Size				0.101***	0.155***	0.128***
Leveradge				-0.0000312**	-0.0000266***	-0.0000201*
Capital intensity				0.0000393	0.00729***	0.0206***
Capital intensity^2				3.67e-08	-0.0000103***	-0.0000307***
NPL / Equity				0.00000285	0.0000133***	-0.0000233***
Observations	108176	108176	108176	99684	99684	99684
Number of industries	82	82	82	82	82	82
Industry fixed effects	YES	YES	YES	YES	YES	YES
R^2 within	0.0325	0.0982	0.0346	0.0390	0.117	0.0495
R^2 overall	0.0373	0.116	0.0423	0.0418	0.132	0.0631
R^2 between	0.0131	0.175	0.221	0.0389	0.330	0.553

Robust standard errors are clustered at the industry level: * p < 10%, ** p < 5%, *** p < 1%.

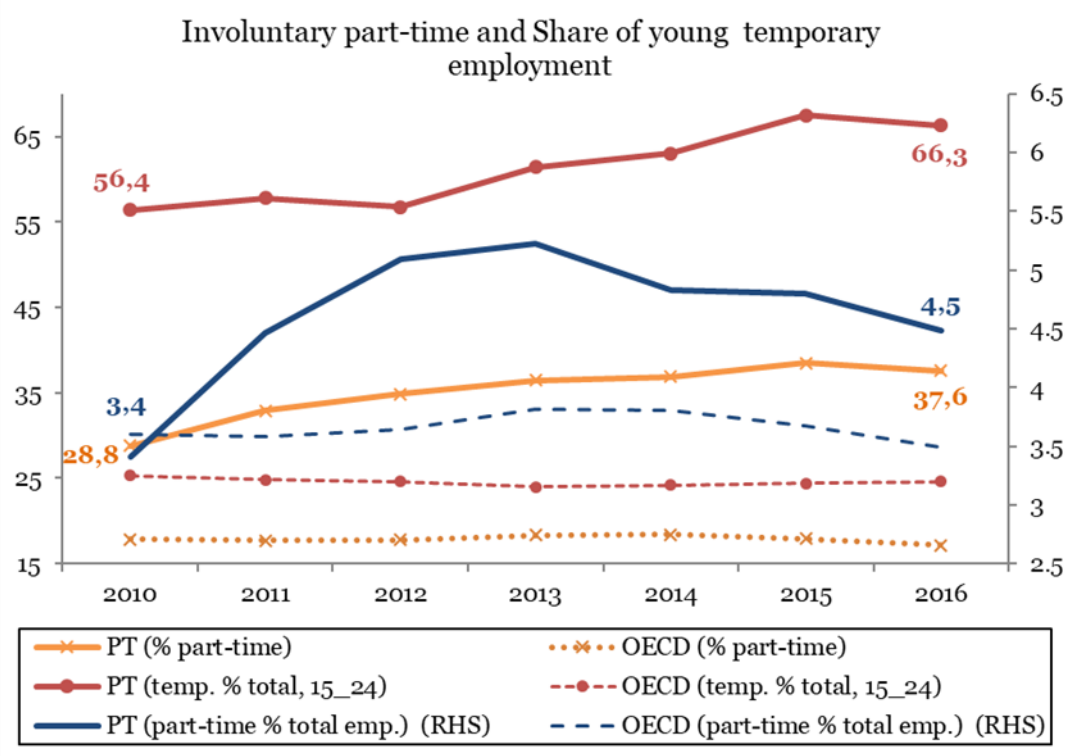
59. As expected, training increases productivity per worker (Dearden et al., 2006), particularly in top-performing companies. A striking result is that companies with higher investments in on-the-job formation for their workers are associated with lower average wages. This might indicate that not only do wage updates from specialisation take time to materialise, but also that, executives substitute wages for training expenses. This does not occur for firms at the bottom of their industry's wage distribution (Q10), likely because a large proportion of their workers already receive minimum wages. This explains the mean decoupling impact of training from Table 3, which is more pronounced in top-performing and high-paying enterprises. Having an exporter status significantly increases productivity (Greenaway et al., 2004) and wages (Wagner, 2002), with the effect on the first being larger – i.e. increasing the ratio. In addition, these effects increase along both distributions, meaning that it is a determinant which also widens the dispersions of productivity and wages.

60. Though not significant for top-productivity firms, irregular contracts significantly decrease productivity for companies at the median and bottom of their industry's productivity distribution. By lowering productivity levels of low-performing firms, non-standard contracts intensify the overall productivity dispersion. In an extensive report, ILO (2006) points to an inverse U-shaped relationship between temporary contracts and productivity. If the share of these contracts is not too high, and if they are voluntary, productivity increases. On the other hand, if firms abuse temporary contracts and these are involuntary, there is a significant negative productivity effect. Thus, our results suggest that top-performing firms may have a culture of hiring stable labor, with a high degree of conversion of temporary into permanent contacts and the former are signed voluntarily. Whereas, in lower-productivity firms, temporary contracts might be renewed several times with the goal of reducing labor costs and appear to be involuntary. *The Green Book of Labor Relations – Portugal* (2016) highlights Eurostat data showing that, in 2015, 68% of temporary workers between 15 and 24 years of age (the most qualified generation ever)

are involuntary, while the EU-28 average is less than half (37,3%).[21] Worryingly, the share of temporary contracts among young employees increased by almost 10pp, in just six years (Figure 8). While the OECD average remained stable around 25%, in 2016 more than two thirds of workers in Portugal, aged between 15 and 24, had temporary working relations.

61. Our measure of irregular contracts also includes part-time workers. In Figure 8 one can see that more than a third of part-time contracts were involuntary in 2016 – more than double the OECD average. These also increased substantially, since 2010, until they represented 4.5% of total employment. Unstable working relations can have adverse productivity effects. Using years of tenure as a proxy for stability in EU-13, Auer et al. (2005) show a positive and robust relationship with productivity growth, until a turning point of 13.6 years – although no EU country surpassed it. The authors argue that stable working relations promote worker commitment, lead to more coordinated tasks between permanent workers and managers, as well as on-the-job training leading to productivity enhancements.

Figure 8. Labor market characteristics of Portugal compared to OECD



Note: Involuntary part-time as a percentage of total part-time and as a share of total employment (Right Hand Side); Incidence of temporary contracts in total employment between 15 and 24 years old.
Source: OECD Labor Force Statistics.

62. Returning to our results, non-standard contracts tend to significantly decrease average wages for all companies, except for high-paying ones where the effect is not significant – i.e. also amplifying wage dispersion. This might be an indication that the mentioned voluntary nature of irregular contracts in top-performing companies arises from the absence of a significantly lower wage. Additionally, the negative effect on wages is more pronounced for companies already in the lowest tail of each industry's wage

[21] The percentage of involuntary contracts in temporary employment is even higher for workers aged between 24 and 65 years (87%), also above EU-28 average (72%).

distribution. The combination of all these effects also contributes to the decoupling of wages from productivity, in all parts of both distributions.

63. Likewise, higher board compensation displays a cubic relationship with productivity, being significantly negative for low-performing companies, while displaying some evidence of having a positive effect on productivity at top-performing firms – i.e. contributes to productivity dispersion. In terms of its effects on wages, higher board compensation is associated with even lower average wages for firms already belonging to the bottom half of their industry's wage distribution. On the other hand, there is no robust evidence that it promotes higher wages in top-paying firms – i.e. also promotes wage dispersion. Therefore, higher board compensation relative to total wage costs might be one of the explanations for the non-significant link between top-half productivity divergence and top-half wage dispersion (90th/50th) identified in Output 1 (visible in Figure 3).

Table 5. Determinants' effects on wages' divergence (denominator)

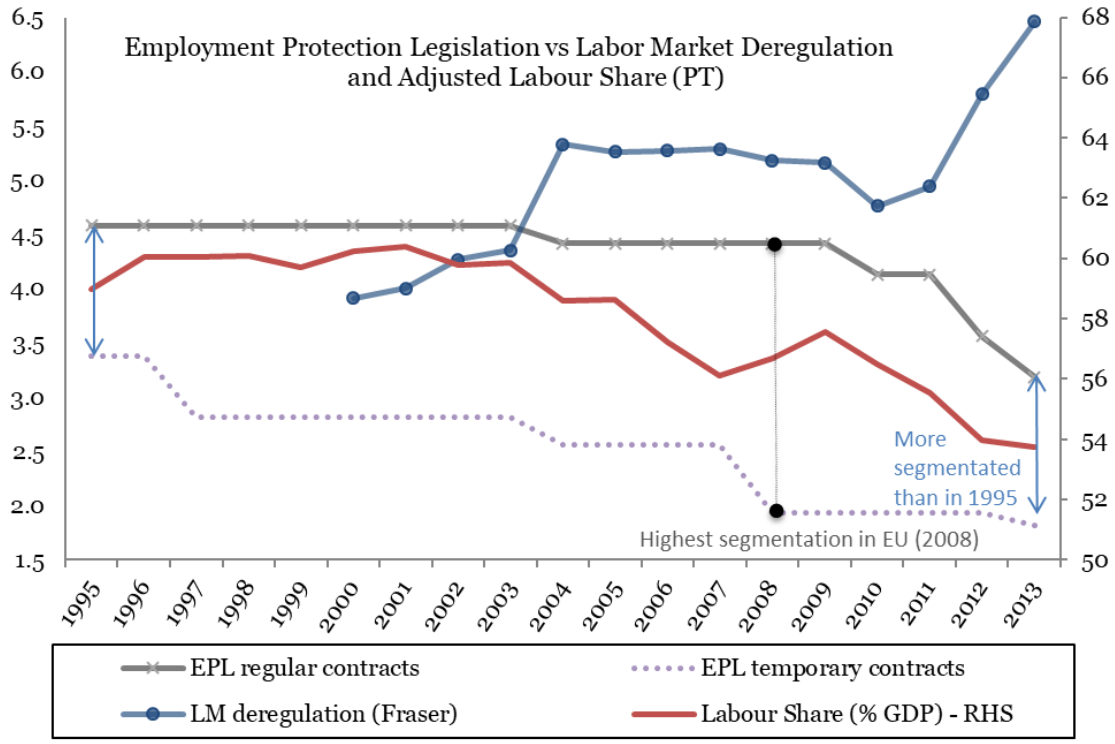
Table 5	Unconditional Quantile Regressions by industry with fixed effects					
Average Wage	(1)	(2)	(3)	(4)	(5)	(6)
log(Wage)	Q(10)	Q(50)	Q(90)	Q(10)	Q(50)	Q(90)
Training	-0.207	-0.487***	-0.303**	-0.204	-0.528***	-0.250*
Export status	0.0787***	0.245***	0.431***	0.0421**	0.129***	0.313***
Irregular contracts	-0.497***	-0.139***	0.0225	-0.507***	-0.145***	0.00872
Innovation status	0.0849***	0.185***	0.172***	0.0619***	0.101***	0.0939***
Electricity costs	-0.000115	-0.266***	-0.344***	-0.0229	-0.313***	-0.374***
Net interest received	0.0139	0.00883***	0.000597	0.0266***	0.00678***	-0.00151
L.M. deregulation	-0.0286***	-0.0236***	-0.0252***	-0.0289***	-0.0130***	-0.0198**
Minimum wage	0.0000928***	0.0000282***	0.00000294	0.0000792***	0.0000295***	-0.000000662
Board compensation	-0.335***	-0.277***	-0.0668*	-0.324***	-0.0969*	0.0872*
Size				0.0853***	0.223***	0.197***
Leveradge				-0.0000316*	-0.0000286***	-0.0000113
Capital intensity				-0.00832***	-0.00354**	-0.00196
Capital intensity^2				0.00000987***	0.00000511*	0.00000379
NPL / Equity				0.00000259**	0.0000101***	-0.00000359
Observations	108176	108176	108176	99684	99684	99684
Number of industries	82	82	82	82	82	82
Industry fixed effects	YES	YES	YES	YES	YES	YES
R^2 within	0.0457	0.0778	0.0426	0.0585	0.124	0.0605
R^2 overall	0.0505	0.0930	0.0524	0.0648	0.134	0.0664
R^2 between	0.0877	0.322	0.158	0.103	0.396	0.177

Robust standard errors are clustered at the industry level: * p < 10%, ** p < 5%, *** p < 1%.

64. Closely related to the high share of irregular contracts is the unwinding of labor regulations (Figure 9). Turning to the decomposed effects of labor market flexibilisation, one can see that, while it does not have an effect on productivity, it significantly decreases wages throughout the whole industry's wage distribution. OECD's (2013) comprehensive literature review points to a trade-off between productivity enhancing impacts from lower EPL – e.g. lower burden implied by firing costs increasing worker flows and, desirably, efficient allocation (Hopenhayn and Rogerson, 1993) – and equally beneficial effects arising from higher employer and employee investment in firm-specific human capital due to greater job protection (Belot et al., 2007; Fella, 2005). Accordingly, analyzing 20 OECD countries for the period 1984-2004, Storm and Naastepad (2009) found that more regulated and coordinated ("rigid") labor markets promote long-run productivity growth. Using a more extended period (1960-2004), Vergeer et al. (2010) show that

wage-cost saving flexibilisation of labor markets has a negative impact on labor productivity growth, finding a causal link between wage growth and productivity growth.

Figure 9. Labor market flexibilisation and Declining labor share



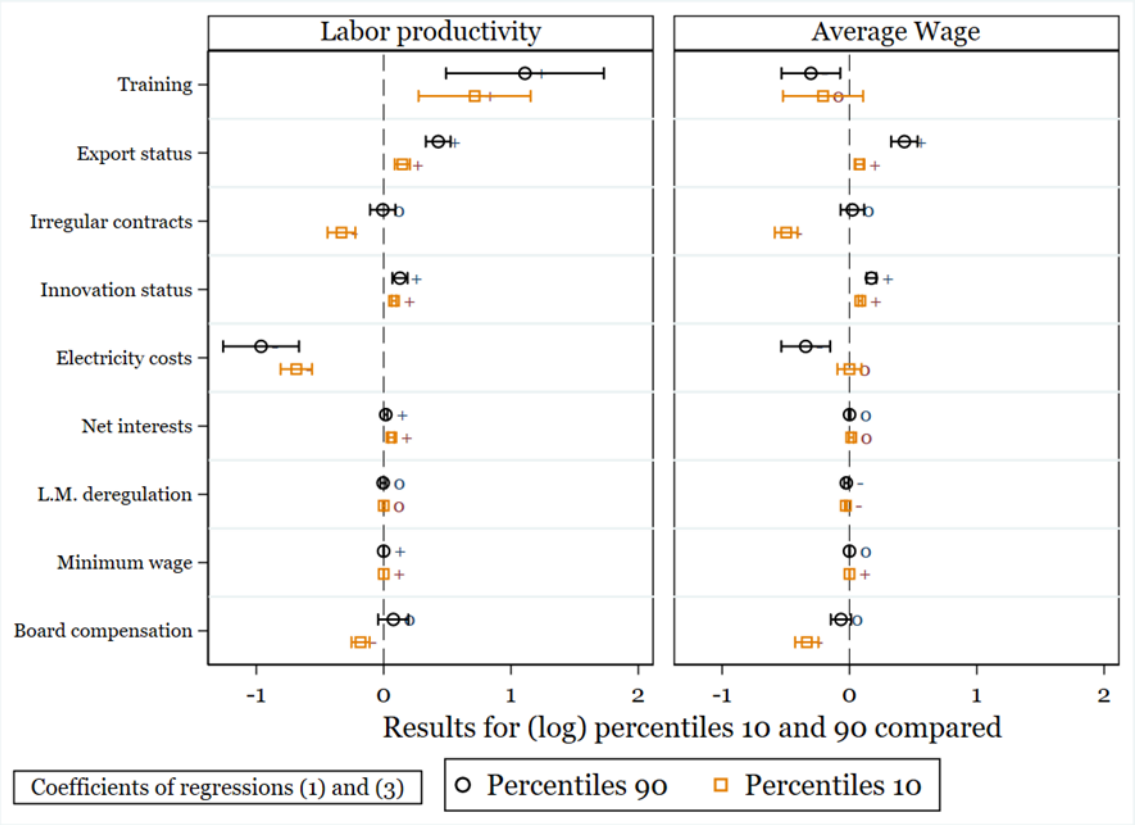
Note: Employment protection legislation composite synthetic indicators for regular contracts and for temporary con-tracts encompass 21 items to measure the strictness of labor market regulations (version 1). The decreases on both series reflect several and distinct reforms, namely those arising from the Memorandum of Understanding sign in 2011. Labor market regulation index is composed of six sub-indices from hiring and firing restrictions to collective bargaining centralisation and fairly follows the inverse trend of the former series. The increased deregulation/flexibilisation of the labor market did not contribute to tackle segmentation as the EPL of temporary contracts continued to diminish. These developments contributed to the sharp fall in the adjusted (for mixed incomes of the self-employed) labor share over GDP.
Sources: OECD-EPL Statistics; Fraser Institute and AMECO.

65. While there is evidence that dualised labor markets hinder productivity growth (OECD, 2004, 2007a, 2010), it is not clear whetherreducing EPL will tackle segmentation per se. In fact, Figure 9 shows that segmentation, in Portugal, actually increased after several reforms vis-à-vis 1995. These reforms intensified the decline of the labor share (the largest fall in EU-28), partially because the protection of temporary contracts was further reduced. The combination of these effects sheds light on how labor deregulation hampers the link between productivity and wages.

66. Annual minimum wage updates are positively associated with higher productivity levels for all companies, as well as with higher wage levels except for high-paying firms. The latter might be explained by a small proportion of minimum wage receivers within top-paying companies. The former might be viewed as evidence that minimum wage improvements also lead to productivity improvements for top-performing companies, likely due to greater aggregate demand for their products and services. These conclusions align with Croucher et al. (2012), who found causal productivity improvements in all low-paying sectors, using a difference-in-difference analysis, after the introduction of a national minimum wage in the UK. Therefore, increasing minimum wages tackles wage inequality (e.g. Carl Lin et al., 2016) and productivity divergence through its positive effects on firms at the bottom halves of both distributions.

67. Regarding financial factors, companies with higher net interests received exhibit higher productivity levels, while the effect on wages is less clear. Finally, larger firms tend to have higher productivity levels and average wages, across the entire distribution.

Figure 10. Results for the determinants of productivity and wage divergences



Note: Visualisation of all the coefficients, and their 95% confidence intervals (CI), from regressions (1) and (3) of Table 4 and 5. One can see if each determinant widens the overall dispersion of GVA per worker on the left panel and their effect on the overall divergence of wages on the right panel. If the 90th percentile regression's coefficient of one covariate is significantly higher than that of the 10th regression – i.e. the lower bound of the former's CI does not overlap the higher bound of the latter – then the covariate increases the dispersion of that distribution. The symbols +, - and 0 state the sign of the significant coefficient or its insignificance, respectively. The regression's table of this Figure can be found in Output 8 of Annex A.

68. Looking at Figure 10 to sum up, there is evidence that only three of our regressors significantly increase the dispersion of both the distributions of productivity and wages: having an exporter status, the proportion of non-permanent contracts and the board's compensation over the total wage bill. The presence of exporting companies in each industry is a factor that widens the dispersion of productivity and of wages, while increasing the means of both distributions.[22] High shares of non-permanent contracts and larger board compensation also contribute to the great divergences in both distributions, but because they significantly decrease productivity and wages among firms at the bottom of both distributions – thus, lowering the overall average of productivity and wages. Companies with an innovation status slightly

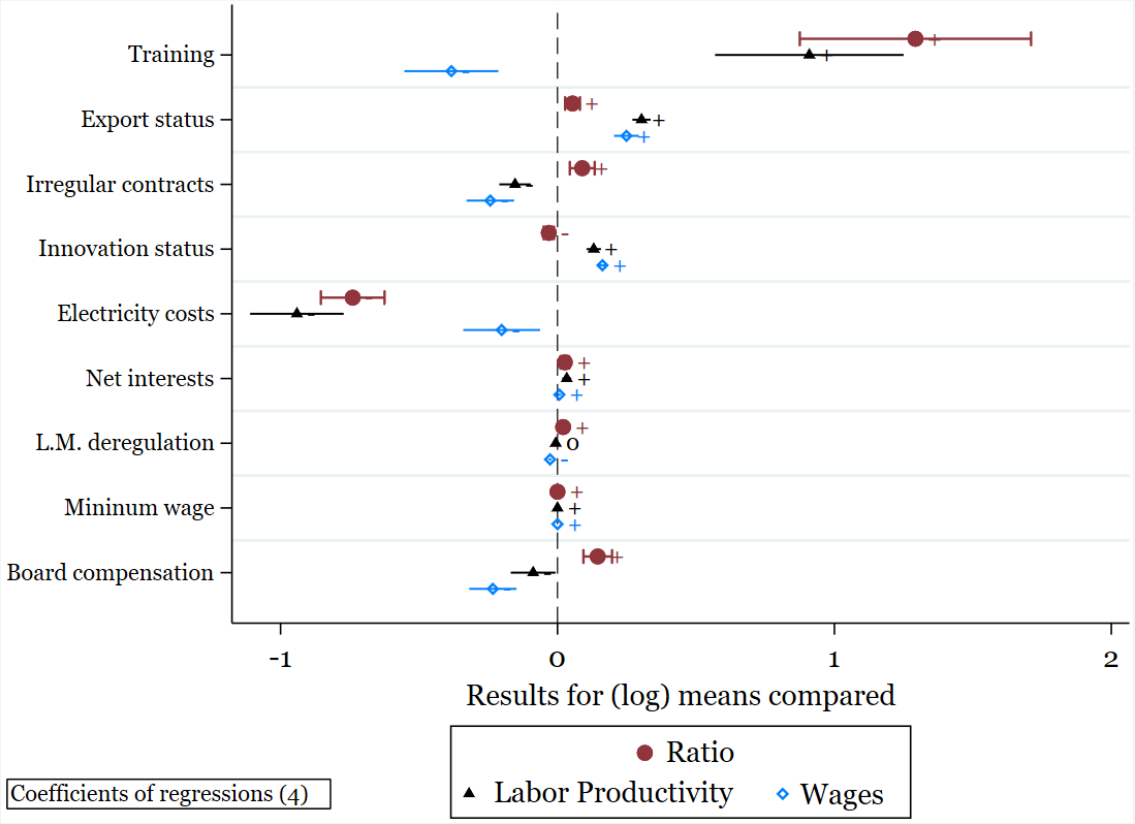
[22] Note that a given determinant could have a positive mean effect on productivity/wages while having negative effects on the 10th and 50th percentiles of the industry's productivity/wage distribution. This could occur because the effect at the top of the distribution would be sufficiently large to offset the negative weights arising from the bottom half of that distribution. Nevertheless, this is not the case for any of the analysed determinants.

widened their industry's wage distribution, whereas higher minimum wages contributed to the equalisation of average wages across firms.

4.3.4. Decoupling through Productivity or Wages?

69. In section 4.3.2 we analyzed some quantifiable determinants of the decoupling of wages from productivity by testing their significance for variations in the (logged) ratio of GVA per worker to the firm's average wage. In the previous section we analyzed how each determinant affected the numerator and the denominator of the ratio (*decoupling*) along both distributions, while assessing how these covariates influenced the dispersions of productivity and wage distributions (*great divergences*). In this final section we apply identical panel regressions, with fixed effects and clustered standard errors at the industry level, to the (logged) ratio (regression (4) of Table 3), as well as to its numerator (logged labor productivity) and to the denominator (logged average wage). This allows us to analyze whether some regressors raise productivity and reduce the decoupling or whether there is a trade-off for some factors that reduce decoupling by diminishing productivity. In addition, it can also tell us if the determinants increase the decoupling while raising both productivity and wage levels or by having distinct negative effects on both.

Figure 11. Results for the determinants of productivity-wage decoupling decomposed



Note: Visualisation of the coefficients and 95% confidence intervals from regression (4) of Table 3 (logged ratio) plus the disentangled effects on the numerator (logged labor productivity) and the denominator (logged average wages). The symbols +, - and 0 state the sign of the significant coefficient or its insignificance, respectively. For example, irregular contracts raise the ratio (decoupling) because the negative effect on average wages is larger than the one on productivity. These results can be found in a regression's table format in Output 7 in the annex.

70. Results are shown in Figure 11 allowing one to clearly visualise not only which factors contribute to the decoupling but also why that is the case, distinguishing factors in terms of their effects on productivity and on wages. As we have seen before, from the determinants of our baseline model, only electricity costs

over EBITA and having an innovation status reduce decoupling, while all others raise it. The difference is that the former reduces decoupling through a larger negative effect on productivity than on wages, whereas the latter through a greater positive effect of wages than on productivity. Furthermore, there are more factors putting downward pressure on wages (five) than on productivity (three) and only two diminish both: the proportion of irregular contracts on the workforce and the relative remuneration of the board. In addition to their negative mean effects on productivity and wages, both these factors raise decoupling. On the contrary, although still raising the ratio, having an exporter status, positive net interest balance and minimum wages have positive mean effects on both productivity and wages. Finally, while on-the-job training expenses raise decoupling (reduce labor shares), by boosting productivity and discounting those costs on wages, labor market deregulation reduces labor shares without any effect on productivity levels.

5. Conclusion and Policy Implications

71. In the last decades, advanced economies have been experiencing a slowdown in productivity growth. At the same time, there is an ongoing debate about the causes of wage stagnation, particularly in a period of low unemployment (*wage puzzle*). While productivity is a crucial ingredient for output growth, it is only a motor of rising living standards if the gains translate into higher wages. Thus, it is crucial to understand how the wage-setting process takes place and what drives the productivity-wage gap.

72. Using administrative data of firms in Portugal between 2010 and 2016, we investigate the relationships between productivity and wages. We find positive and robust associations between productivity and average wages in levels and growth rates, though with noteworthy heterogeneity along the distributions. The link is also significant in terms of overall sectoral dispersions. However, top-half productivity dispersion was not followed by top-half wage dispersion, suggesting that productivity gains of top-performing companies are not being shared with the workforce.

73. Moreover, at odds with the neoclassical theory of marginal product of labor, we find that two thirds of firms did not raise wages in line with labor productivity. These results contribute to two well-documented dynamics: increasing productivity and wage dispersions (*Great Divergences*) and the decoupling of wages from productivity (*Productivity-wage gap*). Focusing on the productivity-wage gap, we find that the ratio of productivity to wages has widened in all major sectors, with the exceptions of Construction and Non-Market Services, which were particularly affected by the crisis. We also show how the pressure for lower Unit Labor Costs translates into lower labor shares and larger decoupling.

74. Furthermore, we assess the influence of some quantifiable determinants of the decoupling and decompose them into numerator and denominator mechanisms, for different parts of each distribution. We argue that labor market flexibilisation/deregulation intensified dualisation, providing incentives for companies to hire using non-standard contracts. Indeed, between 2008 and 2017, Portugal recorded the highest EU increase in 3 months' temporary contracts, after Croatia. The percentage of these very short-term irregular contracts more than doubled relative to total employees (from 1.1% to 2.9%).

75. The pressure for deregulating labor markets is usually justified by its positive effects on tackling unemployment and boosting productivity. However, the literature is, at best, inconclusive regarding both (Betcherman, 2012). The conditions of the EMU limit the capacity of economies to undertake counter-cyclical policies, leaving the channel of *internal devaluation* as one of the main adjustment mechanisms to correct external imbalances. Current account imbalances are "now widely agreed to haven been a major contributor to the persistent economic crisis in the EMU" (Horn and Watt, 2017). In this EC discussion paper, the authors show that *wage policy* alone is not sufficient to correct the "huge German surplus", arguing for nominal wage coordination linked to productivity plus the ECB target inflation, while managing aggregate demand.

76. In our results, flexibilisation significantly decreases wages and has no apparent effect on productivity. In turn, irregular contracts are found to also significantly contribute for the decoupling of wages from productivity. Conversely, minimum wages are positively correlated with both productivity and wages for firms at the median and below, and reinforce the link between the two. Moreover, higher board compensation and exporter companies are associated with a weaker link between productivity and wages. Surprisingly, so do firms which invest more in on-the-job training because, on top of substantial productivity enhancement effects, they discount these costs from wages. These results are robust to a myriad of different specifications.

77. On top of the mentioned methodological issues, this article would significantly benefit from a wider timespan, preferably since the implementation of the euro, and data on individuals. It should be kept in mind that this measure of labor productivity does not, primarily, concern worker effort or ability. Going forward, the use of *Quadros de Pessoal* would allow for the investigation of productivity-wage nexus using matched employer-employee data, unveiling more detailed effects from different types of contracts, as well as the role of within firm wage inequality and educational levels.

78. It is important to find ways to boost productivity, including through well-designed and monitored structural reforms: sound combination of labor and product markets (tackling segmentation[23] and market concentration), in financial markets (namely in adequate credit concessions and regulations) and education (promoting university access and ICT skills).[24] Yet, it is imperative to take into account both efficiency and equity considerations, while acknowledging that a trade-off between the two is not always present. This is particularly crucial when dealing with labor markets, for the panacea of constantly lowering labor costs, in the name of competitiveness, can hamper productivity and will likely break the link between productivity and rising living standards.

> "A productivity strategy that just focuses on businesses and innovations, or that relies on a race to the bottom - via low wages, dismantled social protection, or unacceptable working conditions – to increase the competitive advantage of firms and regions, whilst assuming that eventually everyone will benefit, will ultimately be less effective than a strategy that also addresses the disadvantages that hold people back from contributing to a dynamic economy."
>
> The Productivity-Inclusiveness Nexus - OECD (2018)

[23] Portugal's second Country Specific Recommendation, for 2018 and 2019 states: "Promote an environment conducive to hiring on open-ended contracts, including by reviewing the legal framework in consultation with social partners. Increase the skills level of the adult population, including digital literacy, by strengthening and broadening the coverage of the training component in adult qualification programmes. Improve higher education uptake, namely in science and technology fields."

[24] According to OECD Survey of Adult Skills (PIACC), only 25% of workers use office software and about 40% of them do not have sufficient ICT skills to use them effectively.

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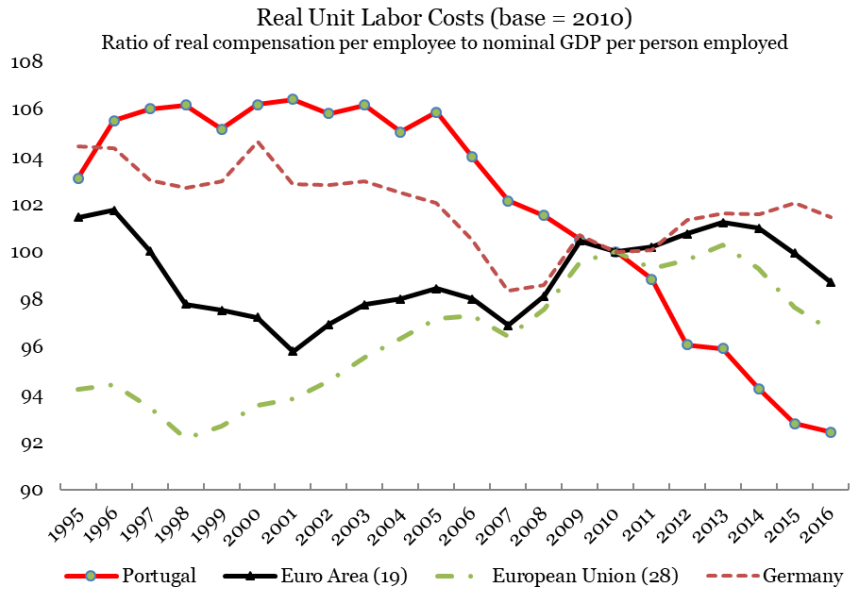
Annex A. Additional tables and figures

Figure A.1. Real unit labor costs compared



Note: Real unit labor costs (ULC). Performance relative to the rest of 37 industrial countries: double export weights (Ratio of compensation per employee to nominal GDP per person employed.) (QLCDQ) from AMECO.

Table A.1. Summary statistics of main variables

	Obs.	Mean	Std. Dev.	Min.	Max.
Labour Productivity	1,144,644	18328	16853	261	202655
Total Factor Productivity	1,135,969	491	3491	0,00	726544
Labour Prod. (hours)	1,144,644	11	10	0,32	108
Average wage	1,144,644	9897	4967	1014	39037
L.P. Growth	819,160	14,7	70,7	-84,8	584,5
Wage Growth	819,160	4,2	25,1	-53,8	153,6
Training	228,291	0,008	0,028	0,00	1
Irregular contracts	831,029	0,068	0,187	0,00	1
Export status	1,144,644	0,073	0,260	0,00	1
Innovation status	1,144,644	0,156	0,363	0,00	1
Electricity / EBITA	649,808	0,157	0,198	0,00	1
Net Interest / EBITA	595,529	-0,053	11,799	-8617	1
L.M. deregulation	1,144,644	5,66	0,58	4,76	6,46
Minimum wage	1,144,644	8048	285	7758	8657
Board compensation	942,999	0,42	0,32	0,00	1

Table A.2. Correlation's matrix of main variables

Correlation matrix	L.P.	TFP	Avg. Wage	Training	Irreg. Contr.	Export	Innov.	Electr.	Net Int.	Labor Mar.	Min. wage	Board
Labour Prod.	1											
TFP	0.0833	1										
Avg. Wage	0.5443	0.1131	1									
Training	0.0467	0.0191	-0.0085	1								
Irreg. Contr.	-0.0041	-0.0049	-0.0294	0.0288	1							
Export	0.1665	0.0279	0.2549	-0.0035	-0.0067	1						
Innov.	0.1129	0.0604	0.2228	0.0129	0.0279	0.2257	1					
Electr.	-0.2296	-0.0331	-0.1324	-0.0188	-0.0043	0.0018	0.0260	1				
Net Int.	0.0173	-0.0031	0.0060	0.0062	-0.0024	0.0010	-0.0013	-0.0155	1			
Labor Mar.	0.0147	-0.0131	-0.0131	-0.0055	-0.0118	0.0282	0.0045	-0.0013	-0.0051	1		
Min. wage	0.0240	-0.0024	0.0004	-0.0124	-0.0107	0.0034	-0.0106	-0.0086	0.0026	0.3392	1	
Board	-0.0081	-0.0626	-0.1454	0.0358	-0.0408	-0.1626	-0.1931	-0.1026	-0.0004	-0.0039	-0.0100	1

Table A.3. Sectoral productivity divergence, upper and lower half

Output 1 - Great Divergences(s) - log Wage (p90/p50) and (p50/10)						
	(1)	(2)	(3)	(4)	(5)	(6)
	log Wage (p90/p50)			log Wage (p50/p10)		
log LP (p90/p50)	-0.0974**					
	(0.0392)					
log TFP (p90/p50)		0.00586				
		(0.0192)				
log TFP_ols (p90/p50)			0.0698			
			(0.0778)			
log LP (p50/p10)				0.218***		
				(0.0581)		
log TFP (p50/p10)					0.119**	
					(0.0545)	
log TFP_ols (p50/p10)						0.136***
						(0.0107)
Observations	134	126	135	134	126	135
Number of sectors	20	18	20	20	18	20
Sector and Year fixed effects	YES	YES	YES	YES	YES	YES
R^2 adjusted	0.109	0.059	0.009	0.224	0.187	0.189

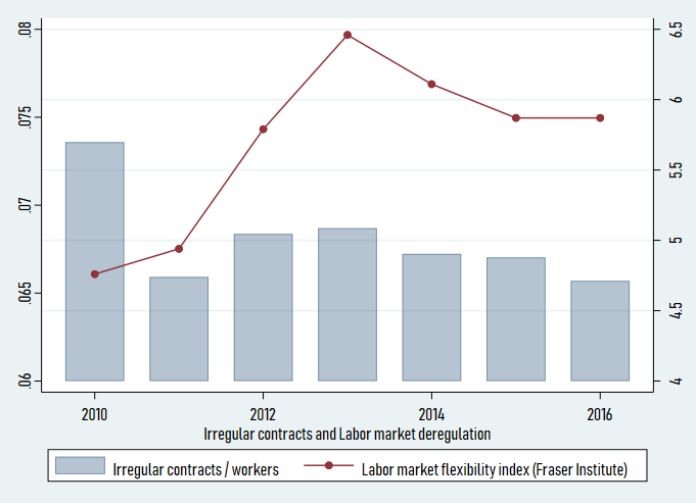
Standard errors are clustered at the sector level and in parentheses : * p < 10%, ** p < 5%, *** p < 1%.

Table A.4. Sectoral wage divergence, upper and lower half

Output 2	(1) log LP (p90/p50)	(2) log TFP (p90/p50)	(3) log TFP_ols (p90/p50)	(4) log LP (p50/p10)	(5) log TFP (p50/p10)	(6) log TFP_ols (p50/p10)
log Wage (p90/p50)	-1.048	0.243	0.198			
	(0.844)	(0.939)	(0.289)			
log Wage (p50/p10)				0.576**	0.650**	0.654**
				(0.226)	(0.237)	(0.233)
Observations	134	126	135	134	126	135
Number of sectors	20	18	20	20	18	20
Sector and Year fixed effects	YES	YES	YES	YES	YES	YES
R^2 adjusted	0.195	0.009	0.024	0.258	0.055	0.127

Note: Standard errors are clustered at the sector level and in parentheses : * p < 10%, ** p < 5%, *** p < 1%.

Figure A.2. Labor market deregulation and share of non-standard contracts



Note: Memorandum of Understanding (2011-2014) significantly increased labour market flexibility/deregulation, facilitating the presence of non-standard contracts (i.e. service providers, temporary and part-time). The 2011's decrease of around 1pp in the latter might be explained by the exiting of low-performing firms, reflected in Figure A.3.

Table A.5. Summary statistics of productivity and wages by sector

Labor Productivity			Total Factor Productivity			Average Wages		
sector	Mean	Std Dev	sector	Mean	Std Dev	sector	Mean	Std Dev
D	55.313	47.595	D	5.661	3.874	D	15.779	7.690
E	31.225	29.524	R	1.621	1.906	O	13.558	5.853
L	28.518	33.543	Q	946	1.000	**J**	13.426	7.391
A	24.168	21.987	F	729	1.186	**K**	12.243	6.493
Q	24.157	19.956	G	446	1.468	E	11.871	5.357
K	23.683	16.396	**H**	309	1.318	**B**	11.505	4.885
J	23.278	18.413	**N**	227	1.081	**M**	11.432	5.918
B	23.092	21.032	S	121	589	P	10.905	4.923
O	21.998	23.119	E	116	249	G	10.407	5.263
M	20.880	17.432	**M**	101	186	**H**	10.329	5.586
H	19.056	14.223	P	100	74	Q	10.251	4.743
G	18.999	16.372	**C**	75	617	**C**	10.161	4.482
N	18.617	17.326	**B**	64	44	**N**	9.813	5.478
R	18.217	18.699	**J**	63	279	L	9.482	5.047
C	18.140	14.957	**A**	46	71	R	9.336	4.975
F	17.370	17.821	**K**	28	50	F	9.270	4.405
P	16.988	12.122	**I**	8	5	**A**	8.924	4.150
S	12.743	11.635	L	5	36	S	8.290	3.740
I	10.732	8.959	O	-	-	**I**	7.526	2.876
Total	**18.328**	**16.853**	**Total**	**329**	**1.101**	**Total**	**9.897**	**4.967**

Tables present the macro sector average and standard deviation for different variables.
Tradable sectors are in bold and based on the methodology proposed by Canas and Gouveia (2016).
Yellow refers to the primary sector; Dotted corresponds to broad industry (secondary sector);
Red for FIRE sectors; Green and White for Market-Services and Non-Market Services, respectively.

1. According to Eurostat, slightly after Germany, Portugal has the highest electricity price for households, being 28% above the Euro Area (EA) average, for the period 2010-2016. Although the situation is less striking when it comes to non-household consumers, prices were still 20% higher than the EA average. Moreover, since 2016, these have been 28% higher than in Spain, with the Portuguese largest generator/company having almost the double of the market share (47% vs 25%). Sector D refer to the production, transportation and sale of energy (electricity, gas, vapour, water and air). High market

concentration should have a big influence on productivity measures and wages. Note, however, that it is also the sector with the highest ratio and lowest correlation between labour productivity and wages.

Table A.6. Summary statistics of productivity-wage nexus by sector

Ratio LP to Wages			Corr(LP, Wages)			Corr(TFP, Wages)		
sector	Mean	Std Dev	sector	Mean	Std Dev	sector	Mean	Std Dev
D	3,55	3,20	O	0,523	0,551	R	0,097	0,619
L	3,25	4,08	P	0,480	0,537	F	0,078	0,583
A	2,89	2,71	**M**	0,450	0,575	**M**	0,070	0,574
E	2,56	2,03	**N**	0,440	0,574	Q	0,070	0,558
Q	2,52	2,30	**K**	0,439	0,654	P	0,058	0,568
K	2,08	1,43	**J**	0,428	0,570	**H**	0,053	0,569
R	2,02	2,01	Q	0,417	0,538	**B**	0,036	0,537
B	2,00	1,61	F	0,399	0,549	**J**	0,011	0,591
F	1,95	2,09	S	0,395	0,557	L	0,011	0,616
H	1,94	1,29	**C**	0,392	0,506	**N**	-0,003	0,592
M	1,94	1,69	**H**	0,387	0,583	**A**	-0,018	0,565
N	1,94	1,61	**I**	0,379	0,557	**K**	-0,022	0,639
J	1,87	1,63	G	0,375	0,531	S	-0,023	0,602
G	1,83	1,38	R	0,368	0,589	**C**	-0,028	0,547
C	1,77	1,24	L	0,320	0,663	**I**	-0,053	0,592
O	1,58	1,15	**A**	0,306	0,540	G	-0,066	0,579
P	1,56	1,03	E	0,271	0,583	D	-0,092	0,539
S	1,51	1,25	**B**	0,260	0,547	E	-0,104	0,568
I	1,41	1,04	D	0,115	0,616	O	-	-
Total	**1,88**	**1,66**	**Total**	**0,388**	**0,542**	**Total**	**-0,015**	**0,578**

Tables present the macro sector average and standard deviation for different variables.
Tradable sectors are in bold and based on the methodology proposed by Canas and Gouveia (2016).
Yellow refers to the primary sector; Dotted corresponds to broad industry (secondary sector);
Red for FIRE sectors; Green and White for Market-Services and Non-Market Services, respectively.

Table A.7. Determinants of decoupling using firm and year fixed effects

Output 3	(1) log(LP/Wage)	(2) log(LP/Wage)	(3) log(LP/Wage)	(4) log(LP/Wage)	(5) log(LP/Wage)
Training	1.160***			1.040***	1.018***
Export status	0.0725***			0.0601***	0.0614***
Non-standard cont.	0.0495***			0.0691***	0.0671***
Innovation status		-0.00543**		-0.00795*	-0.00620
Electricity costs		-0.734***		-0.710***	-0.722***
Net Interest		0.0274***		0.0155**	0.0189**
L.M. deregulation			0.00645***	0.0224***	0.0184***
Minimum wage			-0.00000471	-0.0000176**	-0.0000191**
Board compensation			0.316***	0.159***	0.125***
Size					-0.0272***
Leveradge					-0.00000818*
Capital intensity					0.0139***
Capital intensity^2					-0.0000135***
NPL / Equity					0.00000160***
Observations	152.796	479.444	714.261	108.176	99.684
Number of firms	64.546	150.497	213.504	44.722	41.134
Firm and Year fixed effects	YES	YES	YES	YES	YES
R^2 within	0.0116	0.0814	0.0229	0.0775	0.0933
R^2 overall	0.0134	0.0776	0.0345	0.0854	0.148
R^2 between	0.0183	0.0798	0.0364	0.0887	0.152

Robust standard errors are clustered at the firm level: * p < 10%, ** p < 5%, *** p < 1%.

Table A.8. Robustness checks for determinants of decoupling regressions

Output 4 - Robustness checks - log (LP/wage) ratio						
	(1)	(2)	(3)	(4)	(5)	(6)
	Pooled OLS	Time F.E.	Time and Industry F.E.	Firm F.E.	Random Effects	Subsample[1]
Training	1.426***	1.431***	1.228***	1.007***	1.256***	1.319***
Export status	0.0801***	0.0806***	0.0750***	0.0594***	0.0619***	0.0633***
Irregular contracts	0.102***	0.102***	0.0733***	0.0675***	0.0869***	0.0535***
Innovation status	-0.0290***	-0.0276***	-0.0269***	-0.0108**	-0.0208***	-0.00821
Electricity costs	-0.648***	-0.646***	-0.744***	-0.730***	-0.677***	-0.695***
Net Interest	0.0338**	0.0336**	0.0299**	0.0189*	0.0237**	0.0121**
L.M. deregulation	0.0206***	0.0473***	0.0461***	0.00295	0.00872***	0.0258***
Minimum wage	0.0000503***	-0.00000209	-0.0000122	0.0000181***	0.0000332***	-0.0000226***
Board compensation	0.136***	0.137***	0.123***	0.121***	0.137***	0.153***
Size	-0.0445***	-0.0447***	-0.0440***	-0.0245***	-0.0432***	-0.0266***
Leveradge	-0.00000939*	-0.00000946*	-0.00000887*	-0.00000831*	-0.00000704**	-0.00000608
Capital intensity	0.0180***	0.0180***	0.0148***	0.0139***	0.0154***	0.0127***
Capital intensity^2	-0.0000247**	-0.0000247***	-0.0000199***	-0.0000135***	-0.0000176***	-0.0000127***
NPL / Equity	-0.00000332**	-0.00000315**	-0.00000394***	0.00000167***	0.00000105***	0.00000167***
Observations	99684	99684	99684	99684	99684	85584
Number of firms	41134	41134	41134	41134	41134	35422
Year fixed effects	NO	YES	YES	NO	NO	YES
Industry fixed effects	NO	NO	YES	NO	NO	NO
Firm fixed effects	NO	NO	NO	YES	NO	YES
R^2	0.155	0.156	0.206	0.0892	0.0870	0.0895
R^2 overall	---	---	---	0.146	0.152	0.129
R^2 between	---	---	---	0.150	0.159	0.138

Robust standard errors are clustered at the firm level and available upon request : * p < 10%, ** p < 5%, *** p < 1%.

[1] Subsample corresponds to the main model excluding the following sectors: Agriculture, forestry and fishing; Mining and quarrying; Financial and insurance activities; Public administration and defence, compulsory social security; Education; Human health services; Residential care and social work activities; Arts, entertainment and recreation; Other services; Activities of households as employers; Activities of households for own use; and Activities of extra-territorial organizations and bodies.

Table A.9. Determinants of productivity divergence including wages as a regressor

Output 5	Unconditional Quantile Regressions with Fixed Effects					
Labour Productivity	(1)	(2)	(3)	(4)	(5)	(6)
	Q(10)	Q(50)	Q(90)	Q(10)	Q(50)	Q(90)
Average Wage	0.460***	1.243***	3.651***	0.474***	1.257***	3.731***
Training	9624.1***	18870.7***	65003.0***	9488.7***	18007.4***	58816.0***
Export status	-1.179	1727.0***	6504.7***	86.09	1545.9***	7122.7***
Irregular contracts	-2835.9***	139.8	5182.0***	-2842.1***	-17.28	4165.1**
Innovation status	-15.07	572.9***	-1372.7*	-17.60	289.8	-1513.9**
Electricity costs	-5934.1***	-17104.9***	-31737.5***	-6843.8***	-17888.4***	-31092.0***
Net Interest	613.2***	393.5***	517.2	725.9***	449.9**	674.5
L.M. deregulation	13.72	33.25	467.3	-14.39	46.66	235.9
Minimum wage	1.030***	0.797***	0.519	1.088***	0.986***	1.021
Board compensation	-943.2***	159.2	11212.1***	-982.4***	753.2	10283.4***
Size				41.24	338.7	-2661.4***
Leveradge				-0.237	-0.263*	-0.0714
Capital intensity				19.69**	199.9***	1076.5***
Capital intensity^2				-0.0268**	-0.281***	-1.590***
NPL / Equity				-0.0328	0.0956***	-1.567***
Observations	108176	108176	108176	99684	99684	99684
Number of industries	82	82	82	82	82	82
Industry and Year fixed effects	YES	YES	YES	YES	YES	YES
R^2	0.101	0.322	0.169	0.103	0.328	0.181
R^2 overall	0.115	0.349	0.177	0.117	0.357	0.195
R^2 between	0.224	0.606	0.556	0.221	0.650	0.620

Robust standard errors are clustered at the sector level and in parentheses : * p < 10%, ** p < 5%, *** p < 1%.

Table A.10. Determinants of wage divergence including labor productivity as a regressor

Output 6	Unconditional Quantile Regressions with Fixed Effects					
Average Wage	(1)	(2)	(3)	(4)	(5)	(6)
	Q(10)	Q(50)	Q(90)	Q(10)	Q(50)	Q(90)
Labour Productivity	0.0418***	0.106***	0.326***	0.0451***	0.104***	0.320***
Training	-2479.9**	-7875.7***	-14658.4***	-2479.6**	-8264.2***	-13190.5***
Export status	146.0	1576.8***	5417.5***	-38.08	643.3***	3903.9***
Irregular contracts	-3136.9***	-1183.8***	1179.7	-3103.5***	-1208.0***	1146.4
Innovation status	413.2***	1532.5***	2196.2***	327.5***	895.7***	1348.2***
Electricity costs	986.4***	-226.7	1084.2	971.1***	-697.8	657.8
Net Interest	65.39	27.66	-182.9*	139.9**	2.182	-242.6*
L.M. deregulation	-197.6***	-180.6***	-424.0***	-176.8***	-76.96**	-337.7***
Minimum wage	0.512***	0.181**	-0.323	0.464***	0.186**	-0.442
Board compensation	-2165.3***	-2798.8***	-1162.6**	-2201.4***	-1323.0***	761.5
Size				376.8***	1955.9***	2647.8***
Leveradge				-0.175*	-0.237***	-0.0243
Capital intensity				-73.61***	-84.48***	-183.3***
Capital intensity^2				0.0926***	0.122***	0.284***
NPL / Equity				0.0130***	0.0991***	-0.0896
Observations	108176	108176	108176	99684	99684	99684
Number of industries	82	82	82	82	82	82
Industry and Year fixed effects	YES	YES	YES	YES	YES	YES
R^2	0.0758	0.183	0.178	0.0904	0.221	0.190
R^2 overall	0.0815	0.203	0.191	0.0995	0.240	0.203
R^2 between	0.172	0.547	0.544	0.200	0.555	0.433

Robust standard errors are clustered at the sector level and in parentheses : * p < 10%, ** p < 5%, *** p < 1%.

Table A.11. Results for the determinants of productivity-wage decoupling decomposed

Output 7	Fixed effects by industry		
Models (4)	Means		
	log(LP/Wage)	log(LP)	log(Wage)
Training	1.293***	0.909***	-0.383***
Export status	0.0544***	0.303***	0.249***
Irregular contracts	0.0895***	-0.153***	-0.243***
Innovation status	-0.0314***	0.131***	0.162***
Electricity costs	-0.739***	-0.941***	-0.202***
Net interest received	0.0265***	0.0335***	0.00698**
L.M. deregulation	0.0204***	-0.00617	-0.0266***
Minimum wage	0.0000360***	0.0000693***	0.0000333***
Board compensation	0.145***	-0.0879**	-0.233***
Observations	108176	108176	108176
Number of industries	82	82	82
Industry fixed effects	YES	YES	YES
R^2 within	0.0895	0.115	0.103
R^2 overall	0.0857	0.132	0.119
R^2 between	0.00681	0.184	0.280

Robust standard errors are clustered by industry: * p < 10%, ** p < 5%, *** p < 1%.

Table A.12. Results for the determinants of productivity and wage divergences decomposed

Output 8	Unconditional Quantile Regressions by industry with fixed effects					
Models (4)	Q(10)			Q(90)		
	log(LP/Wage)	log(LP)	log(Wage)	log(LP/Wage)	log(LP)	log(Wage)
Training	0.414***	0.715***	-0.207	2.281***	1.110***	-0.303**
Export status	0.00939	0.147***	0.0787***	0.103***	0.429***	0.431***
Irregular contracts	0.0102	-0.331***	-0.497***	0.212***	-0.00685	0.0225
Innovation status	-0.00902**	0.0813***	0.0849***	-0.0897***	0.128***	0.172***
Electricity costs	-0.381***	-0.686***	-0.000115	-1.100***	-0.963***	-0.344***
Net interest received	0.0303***	0.0602***	0.0139	0.0282***	0.0166**	0.000597
L.M. deregulation	0.0148***	0.000501	-0.0286***	0.0316***	-0.00387	-0.0252***
Minimum wage	0.0000309***	0.000106***	0.0000928***	0.0000441**	0.0000387***	0.00000294
Board compensation	0.0373***	-0.182***	-0.335***	0.336***	0.0759	-0.0668*
Observations	108176	108176	108176	108176	108176	108176
Number of industries	82	82	82	82	82	82
Industry fixed effects	YES	YES	YES	YES	YES	YES
R^2 within	0.0326	0.0325	0.0457	0.0294	0.0346	0.0426
R^2 overall	0.0241	0.0373	0.0505	0.0355	0.0423	0.0524
R^2 between	0.00454	0.0131	0.0877	0.0147	0.221	0.158

Robust standard errors are clustered at the industry level: * p < 10%, ** p < 5%, *** p < 1%.

Table A.13. Labour Market Deregulation and OECD-EPL correlations

	FR_der~M	EPL_rc_1	EPL_rc_3	EPL_r_1	EPL_r_3
FR_dereg_LM	1.0000				
EPL_rc_1	-0.9952	1.0000			
EPL_rc_3	-0.9932	0.9988	1.0000		
EPL_r_1	-0.9952	1.0000	0.9988	1.0000	
EPL_r_3	-0.9932	0.9988	1.0000	0.9988	1.0000

Note: Correlation matrix between Frazer Institute's Labour Market Deregulation index and OECD-EPL of overall and regular contracts (versions 1 and 3)

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