Entry Deregulation, Firm Organization, and Wage Inequality*

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Abstract

This paper identifies a causal link between changes in product market competition, firm reorganization and within-firm wage inequality. We exploit a unique episode of comprehensive firm entry deregulation as a quasi-natural experiment and use exceptionally detailed linked employer-employee data for the universe of private sector firms and workers in Portugal. Following deregulation affected firms flatten their hierarchies: the number of layers is reduced and managers' span of control increased. Dropping a hierarchy layer is accompanied by a significant reduction in wage inequality within the firm, by 8% for the average pay ratio between the top and the bottom layer and 4.4% for the 90-50 percentile wage ratio, showing that there are real changes arising from firm reorganization. Overall wage dispersion, measured by the standard deviation of hourly pay, is also reduced. We discuss mechanisms and interpretations for these changes.

Key Words: Firm entry deregulation, Hierarchy layers, Internal organization, Product Market Competition, Span of control, Wage Inequality.

JEL Classification Numbers: L22, L23, M12, J31.

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1 Introduction

The production of any good requires time, knowledge, and collaboration between individuals and teams. Recent theories have focussed on organizations taking the form of "knowledge hierarchies", where production workers deal with routine tasks and experts specialize on giving directions to solve more complex problems.[1] The organizational choice for a firm is to determine the structure of the hierarchy, given by the number of layers of increasing knowledge and the span of control of experts. Firms tend to change the organization of production in response to shocks, such as deregulation and international trade. Increased competition and uncertainty may induce firms to significantly change their hierarchical structure. The restructuring is then expected to affect wage inequality within firms, as knowledge requirements change across the hierarchy.

Recent research has emphasized the role of hierarchies and organizational practises in explaining firm growth and productivity, and the distribution of wages (e.g., Garicano and Rossi-Hansberg, 2006; Caliendo and Rossi-Hansberg, 2012; Caliendo et al., 2015). However, there is still very limited evidence on what causes firm reorganization, and particularly how competition shocks affect within-firm wage inequality as firms adjust by re-organizing production.

This paper studies how increased domestic product market competition induces firms to change their internal organization and how this change affects wage inequality. We investigate the effect of firm entry deregulation on the structure of a firm's hierarchy, particularly the number of layers and the average span of control of managers. We also study how these changes affect the distribution of wages within the firm and wage inequality. An important contribution of our paper is to identify a causal link between changes in competition in the domestic product market and firms' organizational change and wage inequality. To do so, we exploit a unique episode of comprehensive firm entry deregulation across industries as a quasi-natural experiment, and use exceptionally detailed employer-employee linked data for the universe of private sector firms and all of their workers.

Our main findings are that increased domestic competition reduces firm-level sales and leads firms to flatten their hierarchies: they reduce the number of layers and increase managers' spans of control. Reorganization is accompanied by a reduction in within-firm wage inequality. These results are consistent with knowledge-based and incentive-based hierarchy theories (e.g., Caliendo and Rossi-Hansberg, 2012; and Chen, 2017), which predict that the optimal number of layers increases with production scale. Differences in pay across layers are modelled as a function of knowledge or monitoring effort, respectively, and reducing the number of hierarchical layers affects the distribution of pay and inequality within the firm as skill requirements and incentives change for all workers. At the worker-level, we find that the pay and career transitions

[1] See, e.g., Garicano (2000) and Garicano and Rossi-Hansberg (2006). Garicano and Rossi-Hansberg (2015) provide a review of the literature on knowledge-based hierarchies.

of individual workers are also affected, showing that there are real changes arising from firm reorganization.

To identify the causal effect of increasing domestic competition on organizational change and inequality, we exploit an exogenous change in entry barriers. We use the "On the Spot Firm" (OTSF) program, implemented in Portugal from 2005 to simplify business registration, as a natural experiment. The program created government offices ('one-stop shops') where entrepreneurs can register a new firm in a single visit, while prior to the reform it took 78 days on average, and the requirement to complete numerous procedures and forms, involving visits to several different public offices. The fees were also reduced from 13.5 to 3% of GDP per capita in the "On the Spot Firm" offices (World Bank, 2006, 2008). The reform was implemented in different municipalities over time randomly, and by the end of 2009, 164 municipalities had a one-stop shop, as shown in Figure 1. The initiative was hugely successful, resulting in a significant increase in firm entry. Portugal is now among the countries where starting-up a business is fastest in the world.[2]

[FIGURE 1]

We use the roll out of the "On the Spot Firm" program, the cross municipality-time variation in adoption, to cleanly identify the effect of increased competition on firms' corporate hierarchies and pay structure. To study firm's internal organization and wages, we use comprehensive employer-employee linked data, which tracks each firm and each employee over time. The data has unusually rich and detailed information on workers' characteristics, such as gender, age, education, skill level, occupation, experience, type of contract of employment, hours of work and earnings. We measure changes in organization using hierarchical occupations to define four layers of increasing knowledge and responsibility in the firm, following recent literature (e.g., Caliendo et al., 2015). The data also has information on the firms' industry, location, employment, number of establishments, sales volume, and legal and ownership structures.

To motivate the subsequent empirical analysis of the causal effect of the reform on firm organization and inequality, we start by documenting a positive and significant relationship between the number of hierarchy layers and sales in our data and between the number of layers and within-firm pay inequality, consistent with the theory. Specifically, lower sales are associated with flatter hierarchies and firms with less layers have lower wage inequality, measured by the pay gap between the top and the bottom layer, a measure closely linked to the theory, and by the 90-10 and 90-50 percentile wage gaps, to measure changes in the distribution of pay. Wage variation within firms across layers accounts for 47% of within-firm wage inequality in our sample. Therefore, variation in wages across layers is important to understand the distribution

[2] As a result of the "On the Spot Firm", Portugal rose from 113th to 26th in the World Bank "Ease of Doing Business" ranking of countries and was considered top reformer in business entry in 2005/06 in the Doing Business report (World Bank, 2006).

of wages within firms.[3] We also show that the "On the Spot Firm" program significantly increased firm entry within industries and municipalities and, as new firms enter the market, it reduced firm sales, output and employment of affected incumbents. According to the theory, the negative shock to production scale following the reform is expected to induce firms to reorganize by dropping layers and in turn reduce within-firm inequality.

We find that firms changed the structure of the hierarchy in response to the reform. In particular, our estimates show that the depth of the hierarchy, measured by the number of layers, is significantly reduced and the span of control of top managers increased after the "On the Spot Firm". The effects are largest for firms with three and four layers prior to the reform. The data that we use allow us to obtain estimates that control for observed firm characteristics, as well as for unobserved firm specific heterogeneity. The fact that adoption of the reform varied across municipalities and time allows us to control for municipality-specific and time-specific effects in our specifications. Our finding that firms responded to the negative shock to production scale following the reform by dropping layers is consistent with theoretical results.

We also find that wage inequality decreased after the reform within affected firms that reorganize by delayering, whilst the effect is statistically insignificant for firms that did not change the number of layers, consistent with a reduction in inequality through firm reorganization. Specifically, the reduction in hierarchical layers is accompanied by a 8% drop in the top-bottom-layer pay ratio within firms, relative to the sample mean. We also estimate a 6% reduction in the 90-10 percentile pay ratio and a 4.4% decrease in the 90-50 wage gap within the affected firms that reorganize. The standard deviation of log pay, a measure of overall dispersion, also decreased. We also find that the top-to-bottom layer knowledge gap, measured by formal education (schooling) or labor market experience is reduced within firms. These results are consistent with knowledge-based and incentive-based hierarchy theories, where reducing the number of layers in the hierarchy affects the wage distribution and inequality as the distribution of knowledge and incentives change across the organization. The effects are driven by workers that stay in the same firm after the reform, and are not arising from changes in workforce composition.

Finally, we assess individual-level growth of pay and career transitions after the reform, to paint a more detailed picture of firms' changes in organizational and wage structures in response to the policy change. We find that workers in all layers prior to the reform are more likely to exit the affected firms that reorganize and that stayers in the firm are less likely to be demoted or promoted, with the exception of workers in the bottom layer, which have a higher probability of promotion, within the firm or across firms. The flattening of firms' hierarchies induced by the reform can therefore have lasting consequences on the career paths of individual workers.

[3] This is comparable to Caliendo et al. (2015), who find that 50% of the variation in wages within firms is variation across layers.

We also find that the growth rate of pay increases for workers in the bottom layer, consistent with the reduction in inequality through reorganization.

Our results are related to Guadalupe and Wulf (2010), who show that competition from international trade liberalization, following the Canada-US free trade agreement, leads to flatter firm hierarchies. Our analysis focusses on increased domestic competition, from an exogenous shock to entry barriers. As such, we provide independent evidence of the importance of greater product market competition for firm reorganization. Additionally, our detailed employer-employee data allows us to go further in investigating the real effects of organizational change following a competition shock, particularly the distribution of wages within the firm as well as individual pay and career advancement. In that respect, our paper is related to recent research by Friedrich (2020), who finds that a negative trade shock leads Danish firms to delayer, and dropping a hierarchy layer significantly reduces inequality throughout the organization. We present new evidence of a causal effect of increased domestic firm entry following deregulation on firm organizational restructuring and reduction in within-firm wage inequality.

Our paper contributes to the empirical literature in several respects. Studies that identify a causal effect of competition on firm reorganization and within-firm wage inequality are very scarce. While previous work has focussed mostly on trade shocks, we exploit an economy-wide episode of firm entry deregulation across industries. As such, our natural experiment allows us to obtain results that can be interpreted more generally than for exporting firms, whose organizational and compensation structures may be marked by idiosyncrasies. Moreover, the role of entry barriers is of considerable importance as countries seek to increase competition through deregulation. Evidence of how deregulation can affect firm hierarchies and wage inequality more broadly can have future policy implications for other countries. The staggered nature of the implementation of the OTSF reform over time across municipalities also offers a unique natural experiment to cleanly identify the effects.

Our paper also contributes to the literature that has used theories of knowledge-based hierarchies to understand economic phenomena such as firm productivity, wage inequality, and the gains from trade liberalization (e.g., Caliendo and Rossi-Hansberg, 2012). Caliendo et al. (2015) show that reorganization within French firms, through changes in hierarchical layers of workers, is important to understand how firms grow and contract and the evolution of wages and employment in each layer, as predicted by the theory. In a recent paper, Caliendo et al. (2020) show that Portuguese firms that reorganize by adding a management layer increase quantity-based productivity and decrease revenue-based productivity. A related literature focusses on incentive-based hierarchies, where supervisors, in higher layers, incentivize workers to exert more effort by increased monitoring of subordinates (see Chen, 2017; Chen and Suen, 2019).

Previous studies investigate the effect of product market and entry regulation on labor

market outcomes. Notably, Bertrand and Kramarz (2002) show that entry regulation in the retail sector increased retailer concentration and slowed down employment growth in France. Blanchard and Giavazzi (2003) develop a macroeconomic model to study distribution effects of product and labor market deregulation; the entry of new firms reduces mark-ups thus increasing the probability of unemployment for workers employed in incumbent firms, even as overall unemployment falls. Fernandes et al. (2014, 2018) find that the same reform analyzed in this paper increased the returns to skills and executive compensation at the worker-level, as demand for those workers increases with firm entry. While those studies estimate the effects at the individual-level, conditional on worker skills, and do not condition on changes in hierarchy, this paper studies within-firm pay inequality arising through reorganization - for firms that flatten their hierarchy following the reform - and considering changes in workers' skills.

Finally, our paper contributes more generally to a literature on within-firm wage inequality. Mueller et al. (2017) show that firms with higher pay inequality between top- and bottom-level jobs have higher valuations and stronger operating performance. Song et al. (2019) document the rise in earnings inequality between workers in the US and show that the rise in within-firm inequality occurred mostly within large firms. We show that deregulation contributes to reduce within-firm inequality through reorganization.

The rest of the paper is organized as follows. The next section discusses the conceptual framework that guides the empirical analysis. Section 3 describes the data used and presents descriptive statistics. Section 4 documents stylized facts about the relationship between firm scale, organization and wage inequality. In section 5 we describe the "On the Spot Firm" quasi-natural experiment and outline the empirical strategy. Section 6 presents and discusses the results on the effect of the policy change on firm creation, production scale, changes in the firm hierarchical structure and wage inequality within the firm. The last section concludes.

2 Background framework

Our empirical analysis is guided by the theoretical literature on knowledge-based and incentive-based hierarchies (e.g., Garicano, 2000; Garicano and Rossi-Hansberg, 2006; Caliendo and Rossi-Hansberg, 2012; and Chen, 2017). In knowledge-based models, organizations take the form of "knowledge hierarchies". Production workers, in layer 0 of the hierarchy, solve routine problems and ask agents in the layer above for assistance with problems that they cannot solve. The supervisors or middle managers in turn solve some of the problems and ask agents in the third layer for assistance in solving the rest. Experts, at the top of the hierarchy, leverage their knowledge to solve the most complex problems. In incentive-based theories, supervisors in higher layers monitor subordinates to exert more effort.

Both theories emphasize a positive relationship between production scale and the optimal

number of hierarchical layers. This is because an additional management layer increases fixed costs, as the firm has to pay an additional, and large, wage to the top manager, but it reduces marginal costs as worker productivity increases, through problem solving assistance from experts or increased monitoring, respectively. Thus, adding a layer is profitable if the firms' production increases sufficiently. Conversely, a reduction in production scale may induce firms to drop layers.[4] Firms can thus react to shocks, such as revenue shocks, with organizational changes when the thresholds for restructuring are reached.

When firms change the number of layers, both theories predict that the wage distribution within the firm will also change. In knowledge-based theories, wage differences across layers are a function of knowledge or skills. When firms expand by adding a layer at the top, the knowledge or skill requirement - and thus the wages - at pre-existing layers are reduced as more problems are solved at the top of the hierarchy. Caliendo et al. (2015) document that the new managers are the only ones that earn more in the reorganized firm after adding layers. As a result, wage inequality between top managers and workers increases. Conversely, when firms drop layers, the number of problems solved by agents at all organizational layers increases, increasing the knowledge-content and wages of production work. In incentive-based hierarchy models, wage differences across layers reflect monitoring effort. Adding a layer at the top decreases wages at pre-existing layers as the span of control is reduced and there is less need for incentive-pay; wage inequality within layers decreases but inequality between managers and workers increases (Chen, 2017). In sum, the theories predict that reducing the number of hierarchical layers changes the skill requirements and incentives for all workers thus affecting the whole distribution of pay within the firm.

Consistent with knowledge-based and incentive-based hierarchy models, competition shocks affect organizational choices through production scale. The "On the Spot Firm" program reduced entry barriers and as new firms enter the market, firm-level output and sales are expected to decrease. In line with the theory, the negative shock to production scale induces some firms to reorganize by dropping layers, in turn reducing within-firm inequality. We investigate these responses in the subsequent sections.

3 Data description

The main dataset used in this paper is the Portuguese longitudinal linked employer-employee data *Quadros de Pessoal* (QP), which covers virtually the universe of private sector firms and all of their employees. The data are collected annually, since 1985, by the Portuguese Ministry of Labor and Social Solidarity. Response to the survey is legally mandatory for all private sector

[4] Caliendo et al. (2015) document that adding layers is related to increased value added and dropping them is related to decreases in value added.

firms with at least one employee, and the survey has to be publicly available for consultation. Those two requirements ensure coverage and accuracy of the data. Each firm and each worker are assigned a unique identification number in the data, and can therefore be traced over time. The reference month for the data is October since 1994.

The data has comprehensive and uniquely detailed information on firms and workers, including the firm's employment, sales volume, industry, location, number of establishments, age, legal structure and ownership structure (equity breakdown among domestic private, public or foreign). Worker-level information includes demographic characteristics, such as gender, age, level of education (schooling), and level of qualification; job characteristics, including occupation (according to the International Standard Classification of Occupations, ISCO), type of contract of employment, job tenure, promotions, hours of work, and compensation including wage, seniority payments, regular and irregular benefits and overtime pay.

Importantly for our analysis, in addition to the workers' occupation, it is also mandatory to classify workers in levels of qualification, which are defined by Law. These levels categorize workers according to the complexity, responsibility and skill requirement of the tasks they perform, and reflect layers of increasing knowledge and skills within the firm.[5] We use this information to define four hierarchical layers in the firm: layer 3 includes "Top executives (top management)", layer 2 includes "Intermediary executives (middle management)" and "Supervisors and team leaders"; layer 1 includes "Higher-skilled professionals" and some "Skilled professionals";[6] and layer 0 includes the remaining workers, some "Skilled professionals", "Semi-skilled professionals", "Non-skilled professionals" and "Apprentices, interns and trainees", these categories are typically production workers.

Our analysis covers the period from 2002 to 2009 and includes manufacturing and services firms (46 industries at the 2-digit SIC classification). To study the effect of increased product market competition on firm organization, we will focus on several outcomes: the number of hierarchical layers within the firm, $Layers \in \{1, 2, 3, 4\}$, defined as the number of levels in which the firm reports employees in a year, and the average span of control of managers and other top layers, defined as the number of employees in the layer below per employee in a layer. We also use compensation information in the matched employer-employee data to compute measures of wage inequality within the firm. We obtain each worker's monthly pay by summing the monthly base pay (wage for the normal hours of work), tenure related payments, and regular, irregular, and extraordinary benefits. The monthly pay is deflated to obtain real pay.[7] We then

[5] The eight levels of qualification defined in the Law Decree no. 121/78 of July are the following: 1 – Top executives (top management); 2 – Intermediary executives (middle management); 3 – Supervisors, team leaders and foremen; 4 – Higher-skilled professionals; 5 – Skilled professionals; 6 – Semi-skilled professionals; 7 – Non-skilled professionals; 8 – Apprentices, interns and trainees. Table B.1 in the online appendix describes in detail the hierarchical levels and their skill content in accordance with the law; see also Fernandes et al. (2014).

[6] We include in layer 1 "Skilled professionals" with average pay larger or equal to the median pay of "Higher-skilled professionals".

[7] We use the Consumer Price Index (CPI) from the OECD, with 2005 base year, to deflate the data.

obtain each worker's hourly pay by dividing the monthly pay by total hours of work.

We merge the data with detailed firm-level balance sheet information from the Enterprise Integrated Accounts System (SCIE) dataset, covering the universe of firms since 2004, and the Annual Survey of Enterprises (IAE), its predecessor prior to 2004, covering a sample of around 40,000 firms. This allows us to assess the effect of the reform on firm production scale, measured by the firm's sales volume, output and employment. Finally, to investigate alternative mechanisms, we also merge this data with: (1) the International Trade Customs dataset, providing value and quantity for virtually the universe of firm-product-country export and import transactions, at the HS 6-digit product level; (2) the Annual Survey of Industrial Production (IAPI), with information on values and quantities of all outputs sold (domestic sales and exports), at the 8-digit Prodcom (PC8) level, for a sample of around 15,000 firms; and (3) the Information and Communication Technology Survey (IUTIC) for over 15,000 firms, with measures of ICT use, such as use of email, intranet and extranet. All these datasets are collected by the Office for National Statistics (INE), and are merged with the employer-employee data using the common firm identifiers.

Our main estimation sample excludes firms with only one worker and firms with just one layer prior to the reform, since the within-firm, across layer, inequality measures and the span of control require at least two layers to be computed. We also restrict the sample to firms observed before and after the reform and thus focus on the effects for incumbents. Our specifications control for observable firm characteristics, including the firm's size, age, ownership type, whether the firm is multi-plant and whether it is an exporter. We also account for industry and municipality unobserved heterogeneity and for aggregate shocks, common to all firms. Table A.1 in the appendix reports summary statistics of firm-level variables, for the full sample as well as by firms' number of layers prior to the reform. Individual-level specifications control for observed workers' characteristics: age, tenure, education, and type of contract, as well as for unobserved heterogeneity.

4 Stylized facts: Firm scale, organization and wage inequality

In both knowledge-based and incentive-based hierarchy models, the optimal number of layers is positively related to production scale (Caliendo and Rossi-Hansberg, 2012; Chen, 2017). Adding a layer is profitable if the firms' production increases sufficiently. Similarly, a reduction in firm scale may induce firms to drop a hierarchical layer. The theories also predict a positive relationship between the number of layers and within-firm inequality.

Therefore, in this section we start by presenting stylized facts to document the relationship between firm sales and the number of hierarchy layers, and between the number of layers and pay inequality in our data. This motivates the main analysis of the paper that uses the "On the

Spot Firm" reform as a quasi-natural experiment to study how competition affects firm scale, organization and wage inequality. Tables B.2 and B.3 in the online appendix start by showing the distribution of firm-years by the number and combination of layers, before and after the OTSF program. There is significant variation in the organizational structure, with two or three layers being the most common choices, specifically the combinations of layer 0 and layer 3, and layers 0, 1 and 3 (workers, supervisors and top-management layers, respectively), followed by all four layers.

Figure 2 presents the firm size distribution in the data according to the number of hierarchical layers, in the left panel. It shows clear evidence that firms with a larger number of layers have higher sales. This is consistent with the summary statistics for log firm sales presented in Table A.1. The right panel of Figure 2 shows that there is a positive relationship between the number of layers in the firm and the ratio of average pay of workers in the top layer and those in the bottom layer, the measure of pay inequality more closely linked to the theory. This is also consistent with the statistics for the average top-bottom-layer pay ratio reported in Table A.1, which also shows a similar pattern for the other measures of inequality, the standard deviation of log hourly pay and the 90-10 and 90-50 percentile pay ratios.

[FIGURE 2]

To complement the evidence from Figure 2 and empirically document the relationship between firm scale, hierarchy and inequality at the micro level, controlling for firm observable and unobservable characteristics, we present regression results relating to those relationships. Table 1 documents the relation between production scale and the number of layers. We estimate the following equation:

$$layers_{jt} = \beta \cdot \ln(sales_{jt}) + \gamma \cdot layers_{j,t-1} + d_t + d_j + \epsilon_{jt} \tag{1}$$

The dependent variable is the number of layers in the firm. We control for the number of layers in the previous period, $layers_{j,t-1}$, to account for the effect of previous organizational structure on current scale and organization. We include firm fixed effects (d_j) and time effects (d_t), to absorb firm-specific unobserved factors and aggregate shocks that affect all firms. In column (1) we estimate a linear layers model while column (2) estimates a Poisson model for the count dependent variable. As expected according to the theory, the coefficient estimate of β is positive and statistically significant in both specifications, confirming that there is a positive correlation between firm sales and hierarchy. This is consistent with the cross-sectional evidence from Figure 2. In columns (3) and (4), we account for persistence in firm organization by controlling for lagged layers. Column (3) estimates an OLS model and column (4) uses the system GMM dynamic panel data method, following Arellano and Bover (1995) and Blundell

and Bond (1998), instrumenting for layers and sales using their lagged values.[8] We continue to find a significantly positive effect of sales on firms' hierarchical structure after controlling for lagged layers.

[TABLE 1]

Table B.4 in the online appendix shows the transition probabilities for firms between numbers of hierarchical layers (Panel A). There is significant mobility over time and firms reorganize frequently by dropping layers. Firms with three and four layers restructure most frequently by dropping layers; specifically, 25% and 23% drop layers over the sample period, respectively. This variation in organizational choices is important to identify the effects of the reform on restructuring and inequality. In Panel B, we show that firms are most likely to drop occupational layers at the top, consistent with the theory. Specifically, firms with two or four previous layers drop their top management or middle management layers in the majority of cases, while those with previously three layers dispose of their top management or supervisory levels more frequently.

Exploiting the frequent restructuring in the sample as discussed above, Table 2 investigates the correlation between firm hierarchy and pay inequality within the firm:

$$inequal_{jt} = \beta \cdot layers_{jt} + d_t + d_j + \epsilon_{jt} \tag{2}$$

The dependent variable is pay inequality, measured by either the ratio of average pay of the top layer to average pay of the bottom layer in the firm, the standard deviation of log hourly pay, as a measure of dispersion at the firm-year level, or by the 90-10 and 90-50 percentile ratios of pay as measures of distributional changes. The results in columns (1) to (4) of Table 2, confirm that a higher number of layers is associated with increased inequality within firms, for all measures, consistent with the graphical evidence from Figure 2.[9] We find that reorganizing by adding (dropping) layers is accompanied by an increase (decrease) in pay inequality. An additional layer in a firm is associated with a 24% higher top-to-bottom wage ratio, relative to the average ratio in the sample (column (1)). Column (2) shows that more hierarchy layers are also associated with higher overall pay dispersion within firms. The facts presented in this section are consistent with evidence for French and Danish firms (see Caliendo et al., 2015; and Friedrich, 2020).

[TABLE 2]

[8] We include a maximum of three lags for layers and four lags for sales, while allowing for MA(2) serial correlation in the error term.

[9] It is important to note that this relationship is not mechanical, since we measure firm organization, the hierarchical layers in the firm, based on workers' occupations.

We also find that 50% of total wage variation is captured by within-firm variation, and 47% of the variation in wages within the firm is explained by variation across layers in our sample. This shows that variation in wages across layers is important to understand the distribution of wages within firms.[10]

In the following sections, we use the "On the Spot Firm" reform as an exogenous shock to product market competition, to assess its effects on firms' production scale, organization and pay structure. Since the reform increased competition through a reduction in entry barriers, as new firms enter the market firm-level output and sales of incumbents are expected to decrease, potentially inducing firms to reorganize production reducing the number of layers.

5 The "On the Spot Firm" reform and identification strategy

5.1 Natural experiment for product market competition: the "On the Spot Firm" program

In this section we describe the natural experiment for product market changes that we exploit in this paper: the "On the Spot Firm" reform. In March 2005 a new elected government took office in Portugal and two months later the government introduced the "On the Spot Firm" program. The objective of the program was to reform business registration and reduce the cost and bureaucracy of starting a firm to encourage national and foreign investment. Prior to the reform, to register a new firm in Portugal, an entrepreneur had to visit multiple separate public offices of the Ministries of Justice, Finance, Economy and Labor and Social Security, to obtain the necessary documents and approvals, and was required to complete 20 forms and 11 procedures. The process took on average 78 days and the fees were equivalent to 13.5% of GDP per capita (World Bank, 2006).

The "On the Spot Firm" program (Empresa na Hora), announced by the Ministry of Justice in May 2005, was coordinated by the newly created Agency for Administrative Modernization.[11] The program was implemented in cooperation with various ministries to improve the efficiency of public services and reduce the red tape associated with setting up a new firm. The program made it possible to register a company in a single office – a 'one-stop shop' – in a single visit. Entrepreneurs no longer need to obtain in advance a certificate of company admissibility from the National Registry of Companies or to sign a public deed. During the simplified process, the company identification card and social security number are handed over, and the company receives its memorandum and articles of association, as well as an extract of the entry in the

[10] We follow Caliendo et al. (2015) and obtain the variation in wages explained by cross-layer variation by computing the R^2 of a regression of log hourly wages of workers within a firm on a constant and dummies for layers, and averaging across firms. Those authors find a similar share of 50% for French firms.

[11] https://justica.gov.pt/Servicos/Empresa-na-Hora.

Commercial Register. All of the details are then sent to the tax authorities.[12]

The business registration reform was unannounced and unanticipated. The program introduced the one-stop shops, which are non-profit seeking government offices, where entrepreneurs can register a company at a single office desk in less than an hour. The fees were reduced to 3% of GDP per capita, below the OECD average of 6.8%.[13] Resource constraints and uncertainty about its success implied that the "On the Spot Firm" was not introduced simultaneously in all municipalities. In July 2005 four pilot one-stop shops were opened in the municipalities of Coimbra, Aveiro, Barreiro and Moita.[14] The program was then expanded over time to municipalities across the country. By the end of 2009, 164 municipalities had a one-stop shop. Figure 1 shows the geographical dispersion and opening dates of the one-stop shops across Portugal.[15] As the figure shows, the program was progressively rolled-out across municipalities over time.

The policy was very successful in simplifying business registration. After the reform, the average number of days, procedures, office visits and costs in fees were significantly reduced for entrepreneurs. The reform also significantly increased the number of new firms created.[16]

Our analysis exploits the cross-municipality-time-specific variation in the implementation of the "On the Spot Firm" program to identify the effects on firm organization and pay inequality. Our empirical strategy is based on the assumption that the introduction of the program was not correlated with preexisting trends in the outcomes of interest across municipalities. As an initial test of that assumption, Table B.5 in the online appendix shows that there are no statistically significant differences in pre-reform average growth (over 2002-2004) of any of the outcomes of interest between early and late adopting municipalities. This shows that the order in which municipalities introduced the reform is not correlated with pre-reform trends of outcome variables, supporting our identification strategy.[17]

5.2 Identification strategy

Our empirical strategy uses the "On the Spot Firm" program as a quasi-natural experiment to identify the effects of increased product market competition on firm's internal organization and pay structure. We exploit the roll-out of the program across municipalities over time as an

[12] State-owned firms or firms in industries with industry-specific requirements or permits are not allowed to be registered in the one-stop shops of the "On the Spot Firm" program. These are mainly in the finance, insurance and transportation sectors. We exclude observations in these industries from our analysis.

[13] World Bank (2006).

[14] Administratively, Portugal is divided into 308 municipalities which are the seat of local administrative and executive power.

[15] As discussed in Fernandes et al., (2014, 2018), the rollout of the program is unrelated with the political affiliation of the municipality chief executive.

[16] Portugal is now one of the fastest countries in the world in starting-up a business, and was considered top reformer in business entry in the World Bank "Doing Business" report (World Bank, 2006).

[17] The table reports pre-reform average growth of the variables for the group of municipalities that adopt the reform later (from 2007) in column (1), and for the group that adopt early (in 2005-2006) in column (2), as well as the difference (column (3)) and the p-value for the null hypothesis that the means are equal for both groups (column (4)).

exogenous source of increased firm entry, thus estimating the effects from variation in the timing of the policy change across municipalities. The variable of main interest in our specifications is the reform treatment variable, $OTSF_{mt}$, which takes the value 1 in all periods since the program is adopted in municipality m, and 0 otherwise. We include the variable lagged by one year.[18] Firms and individuals in municipalities that introduce the "On the Spot Firm" program are the treatment group.

In our specifications, among a host of factors that may affect the variables of interest, we include municipality or firm fixed effects, which absorb any potential unobservable differences across municipalities. In addition, we also estimate treatment effects in each year, prior to the reform and after its introduction, to confirm the assumption that the shock was unanticipated. The main empirical specification that we estimate is the following reduced form:

$$y_{jsmt} = \beta \cdot OTSF_{m,t-1} + \lambda \cdot Z_{jt} + d_t + d_j + \epsilon_{jsmt} \tag{3}$$

The dependent variable y_{jsmt} is one of the organizational measures, such as the number of layers or span of control, or one of the wage inequality measures, for firm j, in industry s, municipality m and year t. Z_{jt} includes firm characteristics, such as whether the firm is an exporter, whether it is multi-establishment, ownership type, and age. We control for time effects, d_t, and for firm fixed effects, d_j, or alternatively for industry, d_s, and municipality, d_m, fixed effects. This is a difference-in-differences specification, where the coefficient of main interest, β, on the reform dummy variable, captures the differential effect of the policy for firms in municipalities that adopt the "On the Spot Firm". ϵ_{jsmt} is a white noise disturbance term. We cluster the standard errors at the municipality level, at which the policy was introduced.

We also estimate specifications at the worker-level, to assess whether changes in hierarchy are accompanied by changes in individuals' outcomes in affected firms after the policy. To that end, we estimate the following specification:

$$\begin{aligned} y_{ijsmt} \quad = \quad & \sum_{l=0}^{3} \beta_{1l} \cdot (OTSF_{m,t-1} \times Layerl_{pre\text{-}OTSF,i}) + \sum_{l=0}^{3} \beta_{2l} \cdot Layerl_{pre\text{-}OTSF,i} + \\ & \gamma \cdot X_{it} + \lambda \cdot Z_{jt} + d_t + d_s + \epsilon_{ijsmt} \end{aligned} \tag{4}$$

Here, the dependent variable is one of the individual outcomes: change in the natural log of real hourly pay of worker i in firm j, industry s, municipality m in year t, probability of exit from the firm, probability of demotion or probability of promotion. As above, $OTSF_{m,t-1}$ is the reform treatment variable. We estimate separate effects according to the layer the worker was in prior to the reform; $Layerl_{pre\text{-}OTSF,i}$ is a vector of dummy variables for whether worker

[18] Some municipalities introduce additional one-stop shops in subsequent years. The treatment dummy variable is set to one when the municipality adopts the policy, that is, when the first "On the Spot Firm" office is opened.

i was in layer l ($l \in \{0,1,2,3\}$, where l=3 is a top executive and l=0 a production worker). X_{it} includes individual characteristics, tenure and age and their squares, gender, level of education, and type of employment contract. Firm characteristics are included in Z_{jt}, as discussed above.

We control for year (d_t) and industry (d_s) fixed effects, to estimate the effects on workers' outcomes across treated and untreated municipalities.[19] In alternative specifications, we include worker-firm match fixed effects, d_{ij}, and year dummies, in the compensation regressions. That specification accounts for individual observed skills as well as unobserved heterogeneity in the structure of compensation. The coefficients of main interest in this specification are those in vector β_{1l}, on the interaction terms between the reform variable and the indicators for the occupational layer of the worker prior to the reform. Each element captures the differential effect of the reform on the outcomes of top-managers, middle-managers, higher-skilled professionals and other workers in treated municipalities.

6 Empirical results

6.1 Effect of the "On the Spot Firm" reform on firm entry

Before we assess the firms' organizational response to the product market changes following the "On the Spot Firm", in this section we start by showing that the reform led to significant changes in firm entry, and thus contributed to increase product market competition. In particular, this confirms the use of the exogenous competitive shock to investigate how firms adapted by changing their hierarchical structure. We estimate a specification for the number of new entrants, over the period of analysis, 2002 to 2009:

$$entry_{mst} = \beta \cdot OTSF_{m,t-1} + d_m + d_s + d_t + \epsilon_{mst} \tag{5}$$

The dependent variable, $entry_{mst}$, is the number of new firms in a municipality, industry and year (mst). $OTSF_{m,t-1}$ is the "On the Spot Firm" policy variable, as described in the previous section. d_t are year dummies, which account for aggregate shocks, common to all municipalities, and d_m are municipality fixed effects, which absorb any permanent differences across municipalities in firm entry, in particular between municipalities that adopt the policy and those that do not. We also include industry fixed effects, d_s, to account for time-invariant industry characteristics that may be related to entry. In alternative specifications, we saturate the model further with municipality-specific linear trends, $d_m \times t$, or industry-trends, $d_s \times t$, which absorb any trends in firm entry at the municipality or industry level. ϵ_{mst} is the error term. Standard errors are clustered by municipality.

[TABLE 3]

[19] The results remain robust to including municipality fixed effects.

The coefficient of interest, β, captures the differential effect of the "On the Spot Firm" reform on firm entry in affected municipalities. Table 3 presents the results. Panel A reports results from a linear model for the number of entrants, while in Panel B we estimate a negative binomial specification for the same variable. We find that the "On the Spot Firm" reform is associated with increased firm entry within municipalities and industries. The coefficient on the reform variable, $OTSF_{m,t-1}$, is positive and statistically significant at the 1% level for both the linear and the negative binomial results. The linear estimates imply a 26% increase in the number of entrants within a municipality-industry, relative to average entry in the sample (column (2)). The estimates remain similar when we include industry or municipality time trends (columns (3) and (4)). This result shows that the policy change is associated with a economically significant increase in entry, and thus competition.[20]

Table B.6 in the online appendix estimates the effects of the reform for manufacturing and services sectors separately. The reform significantly increased firm entry in both manufacturing and services, with effects of larger magnitude estimated in the services sector. Table B.7 investigates whether the effects differ across regions. It shows that the reform significantly increased firm entry in all regions except the Algarve, where the coefficient is not statistically significant.[21] The effects are largest in Estremadura, which includes the Greater Lisbon area, and in the North. In sum, the reform significantly increased firm entry across sectors and regions, which has potential policy implications for countries that seek to increase competition through deregulation.

Table 3 estimates the average effect of the policy on firm entry. Next, we also provide event study evidence, estimating the effects in each year. This assesses whether the effects vary with the duration of the program and confirms that the introduction of one-stop shops in particular municipalities and time periods is not correlated with prior trends. We run the following event-study specification for firm entry:

$$entry_{mst} = \sum_{\tau} \beta_{\tau} \cdot OTSF_{m,t=\tau} + d_m + d_s + d_t + \epsilon_{mst} \tag{6}$$

This specification includes a set of dummy variables for each lead and lag τ, with regard to the year of adoption in a municipality, $OTSF_{m,t=\tau}$. We estimate the effects over time, relative to the year prior to the adoption of the policy as the reference period.[22] We continue to include different sets of fixed effects, as discussed above. Figure 3 plots out the estimated coefficients β_{τ} over time, relative to $t-1$, and 95% confidence bands, for the specification with industry time trends, municipality and year fixed effects.[23] The results show that the coefficients are

[20] This confirms our finding in previous work (Fernandes et al., 2014, 2018). Consistent results on increased firm entry following deregulation are reported by Bruhn (2011) for a similar reform in Mexico.

[21] Although with a p-value of 0.12.

[22] All leads equal or prior to $t-4$ are grouped in lead $t-4$.

[23] The results remain almost identical with the other alternative sets of fixed effects.

statistically insignificant in the periods prior to the "On the Spot Firm", confirming that there are no anticipatory effects and supporting our identification strategy. The coefficients become positive and statistically significant after the adoption of the policy and they also increase over time, with an increase in firm entry in affected municipalities.

[FIGURE 3]

6.2 Firm production scale and the "On the Spot Firm" program

We have documented in Section 4 stylized facts of a positive correlation between firm scale and hierarchy and between hierarchical structure and inequality. This is consistent with knowledge-based and incentive-based hierarchy theories, which predict a positive relationship between production scale and the number of layers, and between changes in layers and within-firm inequality, as the knowledge requirements and incentives change across the firm. In this section, we investigate the effects of the "On the Spot Firm" reform on firm production scale, as a motivation for the subsequent analysis that establishes a causal link between competition and firm reorganization and wage inequality. Specifically, we assess whether the competition shock affected firm production scale, thereby inducing firms to reorganize, and in turn change inequality through restructuring, as predicted by the theory.

We use the "On the Spot Firm" program as a natural experiment and estimate Equation (3) for (the ln of) sales, employment and output of incumbent firms as the dependent variables. Table 4 presents the results, which control for firm and year fixed effects. We find that increased firm entry following the reform is associated with a significant reduction in sales, output and employment within firms. Specifically, affected firms reduce sales and employment by 4% and output by 7% on average after the shock. These findings are consistent with theoretical results that lowering entry barriers leads to a fall in firm-level output and sales, with the entry of new firms.

[TABLE 4]

In sum, this section shows that following the reform, firm sales and output decrease. The reduction in production scale may be a channel inducing firms to drop hierarchy layers, as predicted by knowledge-based hierarchy theories. In the next section, we investigate how the reform affects firms' hierarchy and pay inequality.

6.3 The "On the Spot Firm" reform, firm hierarchy and wage inequality

In this section we present the main results of the paper, on the effects of increased entry and competition following the "On the Spot Firm" policy on firms' internal organization and wage structure, particularly pay inequality between the top and the bottom layers of the hierarchy.

In Table 5, we start by investigating the effect of the entry deregulation on the depth of the hierarchy, measured as the number of hierarchy layers in the firm. We estimate Equation (3), with the number of layers as the dependent variable. Columns (1) and (2) estimate a linear model for the number of layers, while in columns (3) and (4) we consider a count model, specifically we use a Poisson model as an alternative specification to the linear layers model of columns (1)-(2). We include firm and year fixed effects in columns (1) and (3), thus estimating the effects accounting for firms' unobserved idiosyncractic characteristics that may affect the hierarchy, as well as for aggregate trends. Alternatively, columns (2) and (4) include industry, municipality and year fixed effects.

The top panel of Table 5 uses the full sample of firms. The estimated coefficient on the reform dummy variable, $OTSF_{m,t-1}$, shows that the increased competition led to a significant reduction in the number of layers within firms in affected municipalities, by 0.124 on average, which corresponds to a 5% reduction relative to the average number of firms' layers in the sample (column (1)). The effect remains similar when municipality and industry fixed effects are included (column (2)). We continue to find evidence for robust negative effects of the reform on firm hierarchies using count models, in columns (3)-(4).[24] These findings provide evidence that the entry reform induced firms to flatten their hierarchies.[25]

[TABLE 5]

In the top panel of Table 5, we estimate average treatment effects for the post-reform period, relative to the pre-reform period. We now present event study evidence of the effects of the reform on firms' delayering. We estimate a specification similar to Equation (6) above, for the number of layers at the firm-year level as the dependent variable. Figure 4 plots out the point estimates of the coefficients β_τ over time, relative to the year prior to the policy change in each municipality, and 95% confidence bands. The event graph shows a structural break after the introduction of the "On the Spot Firm" policy, with a significant reduction in the number of layers for firms in affected municipalities from period $t+1$ onwards. The coefficients are insignificant prior to the reform, showing that there are no pretrends, and supporting the identification assumption that the policy was unanticipated. The timing of the drop in the number of hierarchy layers is consistent with that for the increase in firm entry after the policy change, shown in Figure 3 above.

[FIGURE 4]

The results in the top panel of Table 5 are for the full sample, while in the subsequent panels of the table we estimate the effects separately according to firms' initial number of layers, in

[24] The Poisson results are robust to using a truncated model but it is computationally impractical for the specifications with firm fixed effects given the large number of firms.

[25] Delmastro (2002) studies the determinants of the management hierarchy in Italian plants, and accounts for competition, measured by the Herfindahl concentration index.

the year prior to the reform. For all samples, we find that firms in affected municipalities significantly reduce the number of hierarchy layers after the reform. The effects are larger for firms with initially three or four layers, with a significant 0.25 and 0.34 reduction in layers within firms, respectively, representing an 8% decrease. The results remain similar with municipality and industry fixed effects, with the exception that the effects are not significant for firms with initially two layers.[26]

Having discussed the effects on the depth of the hierarchy, proxied by layers, we now consider the width of the hierarchy, the second variable that defines the hierarchy's structure, measured by the span of control of managers. We define the span of control in each layer as the employment ratio between two adjacent layers. Specifically, the span of control of managers is defined as the number of employees in the layer below per manager. The data do not allow us to assess which employee reports to which manager, so we determine the average span of control of managers at each firm in each year. Table 6 presents the results for the effects of the policy on the span of control of each layer. Columns (1) and (2) report the effect for top managers' span of control (layer 3 of the hierarchy), columns (3) and (4) present the effects on the span of control of middle managers (layer 2), and columns (5) and (6) for workers in layer 1 (supervisors). We include different sets of fixed effects, as above. The top panel is for the sample of all firms, and shows that firms increased the span of control of top managers in response to the reform, by a significant 0.055 when controlling for industry, municipality and year fixed effects. This implies an average increase of around 2.5%, relative to the sample mean. Similar effects are found for middle-managers.[27]

[TABLE 6]

The pooled difference-in-differences results in Table 6 report average estimates after the policy change. In Figure B.1 in the online appendix, we present event study evidence for the effect of the policy on the span of control of top managers. As above, the figure plots the estimated coefficients over time, relative to $t-1$, and 95% confidence bands. The effect on top managers' span of control is insignificant prior to the reform, confirming that there are no pretends, and it becomes positive and statistically significant after the policy change. The coefficients also increase over time, with the duration of the program and the increase in firm entry. The timing is also consistent with the effects on firm entry and the number of hierarchy layers, reported in Figures 3 and 4.

[26] As another robustness check, Table B.8 in the online appendix uses a binary dependent variable for the probability of dropping layers. Consistently, we find that exposed firms are more likely to drop layers after the reform. Table B.9 shows that, consistent with higher entry in services sectors, the magnitude of the effects on firms' delaying is also larger in services than in manufacturing.

[27] The effects are not significant with firm fixed effects. However, the average effect is affected by observations for firms with two layers pre-reform and which do not drop layers, since the span of control requires at least two layers to be computed. Excluding these firms with two initial layers, the span of control of managers becomes positive, significant and of larger magnitude in all specifications. These results are available upon request.

The three lower panels of Table 6 present results for samples of firms according to the pre-reform number of layers. We find that firms with three and four layers prior to the reform are the ones that increase the span of control of top managers in response to the increase in firm entry, consistent with the results for the number of layers. In particular, the estimates of 0.383 and 0.275 in column (1) imply an increase of 18% and 12% in the span of control of top managers within firms with three and four layers, respectively, relative to the sample means. We find that firms with initially four layers also increase the span of control of middle managers, but the coefficient is negative or insignificant for the other samples.[28]

In sum, the results above show that in response to the competition shock, affected firms change the structure of the hierarchy, reducing its depth and increasing the span of control of experts. Our main focus is on firms that restructure by dropping layers following the negative shock to firm scale, consistent with the theory; therefore, in the inequality analysis below, we focus on average effects across all firms, and estimate separate effects for firms that drop layers after the reform.

Next, we investigate the effects of the reform on wage inequality. According to the theory, dropping layers affects pay inequality throughout the organization as knowledge and incentives change for all workers. Specifically, when a layer is dropped, particularly a top layer, the number of problems solved at all layers increases thus increasing knowledge and therefore wages of production work. We therefore expect that firms that restructure after the reform experience a reduction in pay inequality, particularly between the top and the bottom layer. To investigate this prediction, we estimate Equation (3) for measures of wage inequality as dependent variables. As a measure of pay inequality at the firm-level that is closely linked to the theory, we focus on "top-bottom" pay ratios, comparing average pay in the highest hierarchy level of the firm with average pay in the lowest level (see also Mueller et al., 2017; and Friedrich, 2020). We also use the standard deviation of log hourly pay as a measure of overall pay dispersion, as well as the 90-10, 90-50 and 50-10 hourly pay percentile ratios, to measure changes in the pay distribution.

[TABLE 7]

Table 7 presents the results for the top-bottom-layer pay inequality measure. All specifications control for firm and year fixed effects. Column (1) uses the full sample of firms. We find that the reform is associated with a decrease in the gap between average pay in the top and in the bottom layer within firms in affected municipalities. The average effect is negative and statistically significant and implies a 3% reduction in the top-bottom pay ratio, relative to the mean in the sample. Figure B.2 in the online appendix presents consistent event study evidence, similar to previous figures. This finding shows that the delayering following the competition

[28] The negative coefficient for firms with two layers pre-reform is driven by observations where firms do not drop layers as the span of control is not calculated for single-layer firms.

shock, discussed above, is accompanied by a significant reduction in within-firm wage inequality. For example, eliminating a top-management layer is predicted to reduce the wage gap between managers and workers, as with less assistance from a higher layer, the number and complexity of problems solved, and thus the knowledge content and wages of workers increase.

To confirm that the reduction in wage inequality arises through changes in organizational structure induced by the policy, we estimate the effects separately for firms that reduce the number of layers after the reform, in column (2), and for those that do not change the number of layers, in column (3). We find that the reduction in pay inequality within firms is observed only for firms that reduce the number of layers, while the effect is statistically insignificant for firms that do not change the hierarchy. For firms that delayer, the coefficient on the reform variable is negative, highly significant and of larger magnitude than the average effect for all firms. In particular, firms that reduce hierarchical layers experience a 0.153 reduction in the top-bottom pay ratio after the reform, implying an 8% decrease relative to the sample mean. This finding suggests that the reduction in inequality arises through firm restructuring induced by the reform, as predicted by the theory, rather than as a direct effect of the deregulation.

In columns (4) to (6) of Table 7, we use the sample of workers that stay in the same firm after the reform to compute the measures of inequality, to assess whether the effects are driven by composition effects. We find that the results are driven by changes induced by the reform for continuing employees and are not therefore arising from changes in workforce composition. Specifically, the change in inequality among stayers is economically large relative to the overall change, implying a reduction in top-to-bottom inequality of 11% for firms that reorganize (column (5)), which means that this margin is the main adjustment through which restructuring changes the wage distribution within firms.

[TABLE 8]

Table 8 uses as alternative measures of pay inequality the standard deviation of log real hourly pay as well as the 90-10 and 90-50 percentile ratios of pay. The table reports results for the sample of all firms in Panel A, for the sample of firms that reduce the number of layers after the policy change in Panel B, and for the sample of firms that do not change the number of layers in Panel C. We find that the standard deviation of hourly pay decreases after the reform within affected firms, showing that there is a reduction in overall pay dispersion. The results also show that the reform is associated with a reduction in the 90-10 and 90-50 pay gaps, thus affecting the pay distribution within firms. The estimates are larger and more significant in the sample of stayers (columns (4) to (6)), confirming that the reduction in inequality is driven by changes for continuing employees after the reform.

Importantly, results in Panel B show that the effects are larger and economically more significant for firms that drop layers after the reform, compared to the average estimates for all

firms, while the effects on inequality are statistically insignificant for firms that do not restructure (Panel C).[29] Therefore, the reduction in within-firm inequality is driven by reorganization following the competition shock, consistent with the previous results. Specifically, delayering is accompanied by a 2.3% reduction in overall dispersion of pay (column(1)) as well as a drop in the 90-10 percentile pay ratio of 0.14 (column (2)) and a decrease in the 90-50 gap of 0.074 (column (3)); the magnitude of these estimates corresponds to a reduction of 6% and 4.4% relative to the sample mean ratios, respectively. The effects continue to be larger for stayers in the firm.

To further illustrate the difference in wage inequality effects according to firms' organizational response, in Table A.2 in the appendix, we estimate separate coefficients for the effects of the reform on inequality according to whether firms chose to delayer in response to the shock or not. We find a large and statistically significant reduction in wage inequality for firms that drop layers after the reform, relative to other firms in affected municipalities ($OTSF \times drop$ interaction). Dropping layers after the OTSF reform is accompanied by a 0.258 reduction in the top-bottom pay gap, corresponding to a 13% drop, while affected firms that did not reduce the number of layers experience an increase in the gap. For the other inequality measures, we continue to find that exposed firms that reorganize experience a reduction in pay inequality, while the effect for other firms is not statistically significant. This confirms the results in Tables 7 and 8, that changes in pay inequality are driven by those firms that choose to reorganize after the reform.

Table A.3 in the appendix investigates the effects on within-firm inequality for samples of firms according to the layer dropped, to assess whether the effects are driven by firms that drop the top layer, a middle layer or the bottom layer. Hence, for this table we rank the layers in the firm in a year, rather than keeping track of the specific occupational categories.[30] We find that top-bottom-layer pay inequality, the measure more closely linked with the theory, is significantly reduced after the reform for firms that drop any type of layer (Panel A). This is consistent with the theory, as changing the number of layers affects the whole wage distribution within the firm due to changes in skill requirements and incentives for all workers. The largest effects are estimated for firms that drop the top layer, in line with theoretical predictions. For the percentile pay ratios (Panels B and C), inequality is significantly reduced for firms that drop the top or the bottom layer but the effects, though negative, are not statistically significant for those that drop a middle layer.

In Table A.4 in the appendix, we examine changes in within-firm inequality of knowledge or skills. Panel A reports results for the top-bottom layer education (schooling) ratio, and Panel

[29] There is an exception of a small negative coefficient for the standard deviation of log pay.

[30] For example, a firm with two layers: layer 2 (middle-managers) and layer 0 (workers), has a top layer (middle-managers) and a bottom layer (workers). For firms with four occupational layers, the two middle layers (middle-managers and supervisors) are included in one "middle" layer.

B uses experience to proxy for knowledge. We find that the reform reduces within firm skill inequality, contributing to a relative increase in the skill level of workers at lower layers. This is consistent with theoretical results of an increase in the knowledge content of production work as firms delayer (e.g., Garicano and Rossi-Hansberg, 2006). We perform separate analysis for all workers (columns (1) to (3)) and for stayers in the firm after the reform (columns (4) to (6)), and find that the results arise though an increase in the knowledge of continuing employees. The estimates are larger and more significant for firms that drop layers.

The evidence presented in this section, that dropping a layer is accompanied by a reduction in inequality within firms, is consistent with knowledge-based and incentive-based hierarchy theories, where reducing the number of layers affects wage inequality due to changing skill requirements and incentives (e.g., Caliendo and Rossi-Hansberg, 2012; Chen, 2017). In particular, knowledge-based theories predict that if firms contract by dropping a management layer, more problems are solved at each layer, as there is less problem-solving assistance from a higher layer, and thus the knowledge or skill requirement of each layer increases, since workers in lower layers now have to solve more complex problems. And since wage compensates for skills or knowledge, wages increase at lower layers, reducing inequality between managers and workers (Caliendo et al., 2015; Garicano and Rossi-Hansberg, 2006). Even if firms drop other layers, changes in skill requirements and incentives throughout the organization will affect within-firm pay inequality.

6.4 Worker-level outcomes

The matched employer-employee data that we use allows to also estimate individual-level outcomes. This assesses in more detail how firms reorganize and how reorganization affects workers' pay and career transitions. We estimate the effects on individual wage growth, as well as on the probability of demotion, promotion and exit for workers in firms affected by the policy, according to the layer of the worker in the year prior to the reform.

We estimate Equation (4), for the log difference in real hourly pay at the worker level, the probability of demotion, promotion and exit from the firm, as the dependent variables. Demotion is defined as a move to a lower layer, while promotion is a move to a higher layer. We estimate linear probability models for the probability of promotion, demotion and exit. We control for each worker's observable characteristics: education, quadratic in tenure and type of employment contract, and for firm characteristics: age, ownership, whether the firm is an exporter or multi-plant.

Table 9 reports the results for the sample of firms that reorganize by dropping layers after the reform. Columns (1) and (2) present results for the growth in pay. We include worker-firm match fixed effects in column (1), and thus estimate the effect of the policy from workers that remain in the same firm after the reform, while absorbing worker's unobservable skills and ability. We also always control for year dummies. We find that the growth rate in compensation

(log difference in pay) increases after the reform for workers in layer 0 prior to the reform, while the effects are not significant for workers in other layers. Specifically, delayering is accompanied by a 2% increase in wage growth of production workers after the reform. The results are similar when we include industry and year fixed effects (column (2)), thus estimating the effects for all workers, within industries. The increase in pay growth of production workers in firms that delayer is consistent with increased problem solving when firms reorganize. The worker-level results in this section control for observable and unobservable worker skills and are therefore not reflective of heterogeneous workers' skill differences. The results in the previous section, of a reduction in pay inequality at the firm-level, capture the role of worker skills, consistent with knowledge-based hierarchy predictions that dropping layers changes skill requirements across layers.

[TABLE 9]

Columns (3) to (7) of Table 9 report results for worker mobility, for all workers and for stayers in the same firm. The coefficients on the interaction terms between the reform variable and the indicators for the pre-reform layer of the worker show that middle managers (layer 2) and supervisors (layer 1) are less likely to be promoted to a higher layer after the reform, within or across firms, while workers in layer 0 are the only ones with a higher probability of promotion, e.g. to a supervisory position (columns (3) and (4)). We also find that workers are less likely to be demoted after the policy change (columns (5) and (6)). In column (7), we find that across all layers, workers are more likely to exit the affected firms after the reform, by 2.5 to 5 percentage points, depending on the layer of the worker prior to the reform. Workers in layers 3 (top management) and layer 0 (production workers) have the highest probability of exit.

The results in this section show that the decision of firms to reorganize following the competition shock affects workers' pay and career trajectories. In particular, workers are more likely to exit the firm and less likely to be promoted, within or across firms, with the exception of workers in the lowest layer prior to the reform. The increased competition and the flattening of firms' hierarchies it induced can therefore have lasting consequences on the career progression of individual workers.

6.5 Alternative mechanisms

In previous sections, we discuss that the competition shock affects organizational choices through production scale. In line with the theory, the negative shock to production scale following the reform induced firms to reorganize by dropping layers, in turn leading to a reduction in inequality. This section investigates alternative channels through which the competition shock may affect organizational change and wage inequality within firms. In particular, we investigate

the role of product change, outsourcing, and technology change as alternative mechanisms. Changing the type of products produced and exported, changes in outsourcing, or adoption of new technologies in response to the competition shock are the type of adjustments that could accompany changes in the hierarchical structure. If that was the case, the effect on wage inequality could partly reflect these changes through their effect on layers.

To analyze if there is an effect of the OTSF reform on firms' product mix, outsourcing or technology adoption, we exploit data from firms' balance sheets, international trade, product-level sales data and information and communication technology (ICT) use, from surveys of industrial production and ICT.[31] The results presented in Table 10, Panel A, show that there is no statistically significant effect of the reform on the product mix, measured by the number of new products produced (at the Prodcom 6-digit level) or exported (at the HS6 level), or the destination mix, measured by the number of new export countries (columns (1) to (3)), at the 5% level. In columns (4) and (5), we investigate the role of outsourcing, measured by the share of imports in total firms' material purchases and by the share of purchased materials in total firm sales. We do not find evidence of a change in outsourcing after the OTSF program.

[TABLE 10]

In Panel B of Table 10, we investigate if the shock affected firms' investment in R&D and use of information and communication technology, specifically the use of email, intranet and extranet. Knowledge-based hierarchy models also emphasize how ICT affects organization through their impact on how individuals acquire and use their knowledge (Garicano and Rossi-Hansberg, 2006, 2012). Improved communication technology economizes on the time agents spend communicating with others, thus increasing centralization as more problems are solved at the top of the hierarchy. Increased use of ICT could thus affect hierarchies. However, the results show that the reform did not have a significant effect on investments in R&D or in the use of ICT within firms.

In sum, this section shows that there is no evidence of product or technology upgrading in response to the shock in the sample. Changes in product mix, outsoucing or technology use are therefore not driving firms' delayering after the reform, supporting the production scale channel for the effects.

7 Conclusion

This paper investigates the effect of increased domestic product market competition, on firms' internal organization and wage inequality. We investigate the effect of entry deregulation on the structure of a firm's hierarchy, measured by the number of layers and the average span of

[31] The number of observations is therefore significantly lower for these estimations.

control of managers. We then study how these changes affect the distribution of wages within the firm and wage inequality. An important contribution of our paper is to identify a causal link between changes in competition in the domestic product market and firms' organizational change and wage inequality. To do that, we exploit the "On the Spot Firm" program, a unique episode of firm entry deregulation, implemented in Portugal from 2005, as a natural experiment. Our identification strategy uses the roll out of the program across municipalities over time as an exogenous source of increased entry and competition. We use uniquely detailed linked employer-employee data for the universe of private sector firms and all of their workers.

We show that the reform significantly increased firm entry within industries and municipalities. The increased firm entry following the policy change is associated with lower firm sales, output and employment within firms. In both knowledge-based and incentive-based hierarchy models, the optimal hierarchical structure is related to firm production scale. Consistent with theoretical results, we find that affected firms respond to the shock by reducing the number of hierarchy layers and increasing the span of control of managers.

The flattening of the firm following the reform is accompanied by a reduction in pay inequality within firms. Firms that drop layers experience a significant reduction in inequality between workers in the top and those in the bottom layer of the hierarchy. The magnitude of the effect is estimated at an 8% reduction on average in the top-bottom-layer pay ratio after the reform. We also find that the standard deviation of hourly pay as well as the 90-10, 90-50 and 50-10 percentile pay ratios decrease for affected firms. These findings are consistent with knowledge-based and incentive-based hierarchy theories, in which reducing the number of layers affects the wage distribution and inequality as workers' skills and incentives change. The effects are driven by workers that stay in the same firm after the reform, and are not arising from changes in workforce composition.

The matched employer-employee data also allows us to estimate worker-level outcomes. We find that workers are more likely to exit the firm and less likely to be promoted or demoted, within or across firms. The effects of the reform and the flattening of firms' hierarchies, can therefore have lasting consequences on the pay and career progression of individual workers.

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9 Tables and Figures

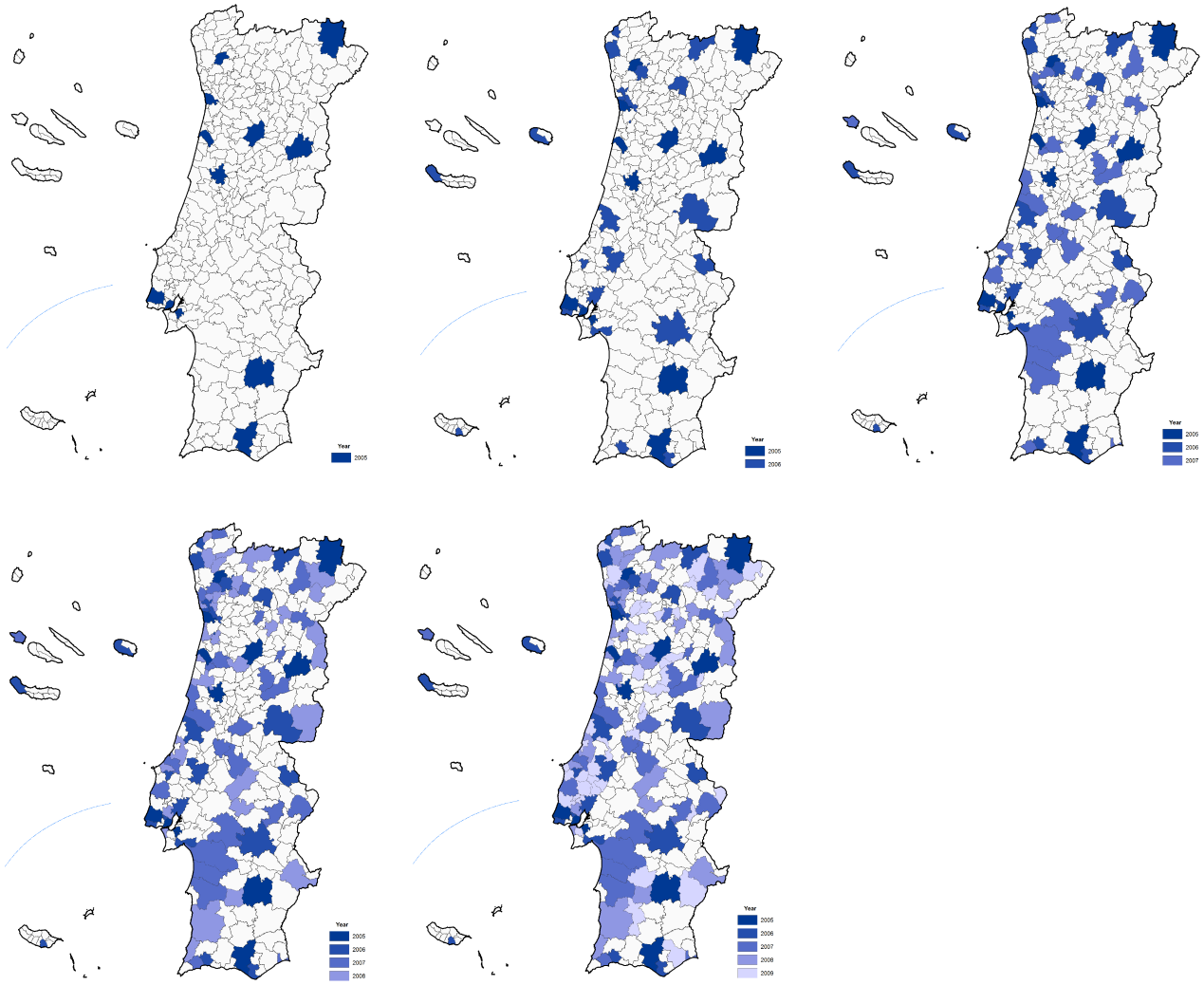

Figure 1: Introduction of "On the Spot Firm" one-stop-shops by year and municipality, 2005-2009

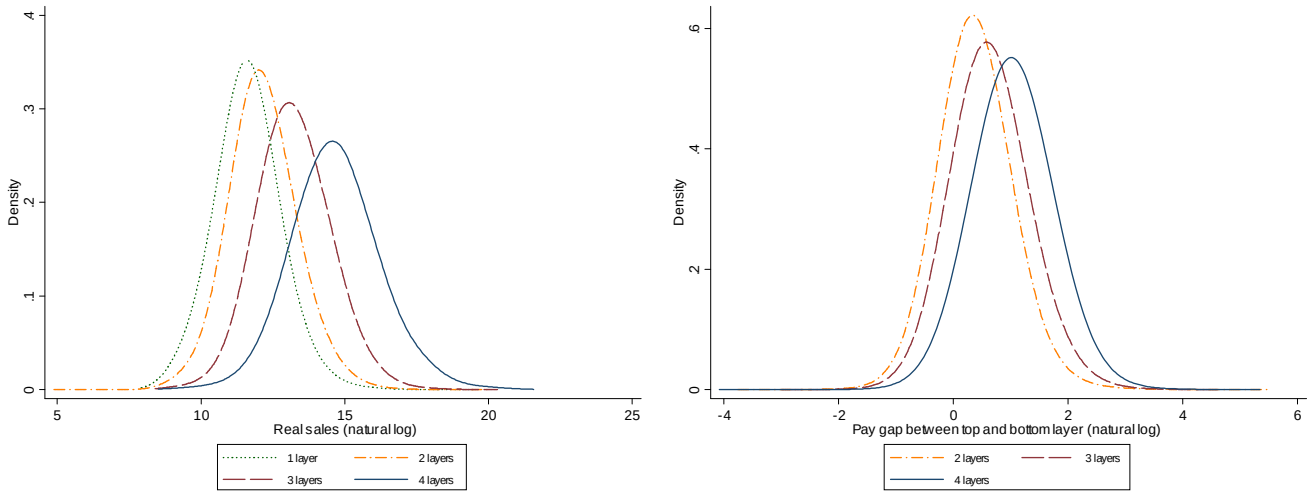

Figure 2: Distribution of sales and pay inequality by firms' number of layers

Table 1: Firm production scale and hierarchy

Dependent variable:	$layers_t$			
	OLS	Poisson	OLS	GMM
	(1)	(2)	(3)	(4)
$\ln(sales_t)$	0.116***	0.048***	0.086***	0.141***
	(0.004)	(0.001)	(0.004)	(0.009)
$layers_{t-1}$			0.182***	0.662***
			(0.004)	(0.008)
Firm fixed effects	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes
No. Obs.	565,405	563,136	478,455	478,455

Observations are by firm-year. The dependent variable is the number of hierarchical layers in the firm. Robust standard errors, clustered by municipality are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table 2: Firm hierarchy and wage inequality

Dependent variable:	top-bottom layer pay ratio	std. dev. ln(hourly pay)	90-10 pay ratio	90-50 pay ratio
	(1)	(2)	(3)	(4)
$layers_t$	0.485***	0.061***	0.433***	0.240***
	(0.043)	(0.001)	(0.022)	(0.015)
Firm fixed effects	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes
R^2	0.008	0.052	0.002	0.002
No. Obs.	279,105	500,141	587,169	587,169

Observations are by firm-year. Robust standard errors, clustered by municipality are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table 3: Effect of the "On the Spot Firm" program on firm entry

Dependent variable:	number of new firms			
	(1)	(2)	(3)	(4)
Panel A: OLS				
OTSF reform	4.307***	0.624***	0.626***	0.617***
	(0.902)	(0.199)	(0.199)	(0.198)
R^2	0.183	0.344	0.344	0.344
No. Obs.	56,257	56,257	56,257	56,257
Panel B: Negative Binomial				
OTSF reform	1.250***	0.095***	0.095***	0.092***
	(0.169)	(0.021)	(0.021)	(0.021)
Marginal Effect	4.939***	0.242***	0.244***	0.236***
	(1.260)	(0.055)	(0.055)	(0.055)
R^2	0.133	0.291	0.291	0.291
No. Obs.	56,257	56,257	56,257	56,257
Industry fixed effects	Yes	Yes		Yes
Municipality fixed effects		Yes	Yes	
Year fixed effects	Yes	Yes	Yes	Yes
Industry time trends			Yes	
Municipality time trends				Yes

The *OTSF* variable, for municipality-years with "On the Spot Firm" one-stop shops, is lagged one year. Observations are by municipality-industry-year. Robust standard errors, clustered by municipality are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

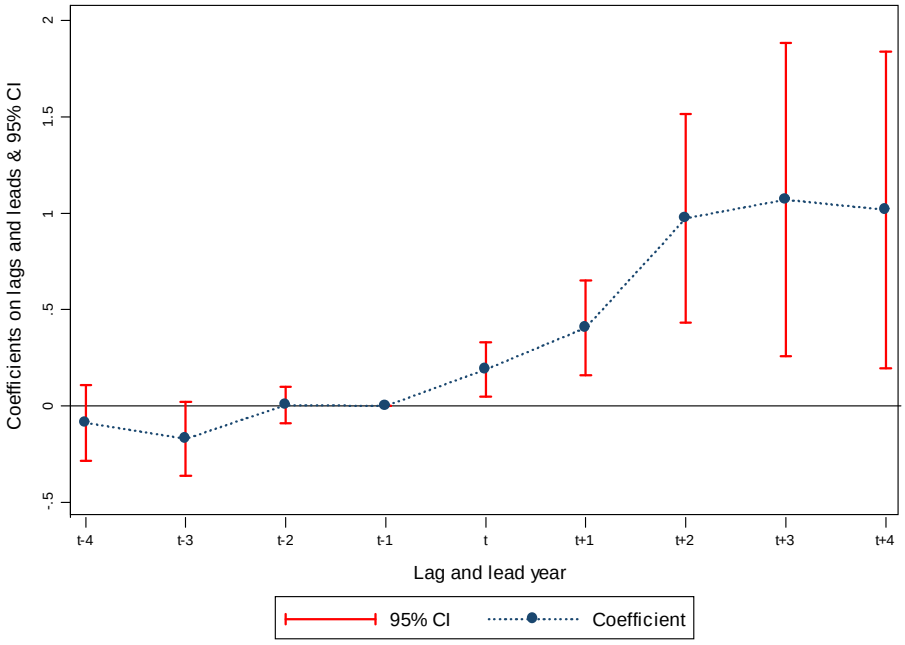

Figure 3: Effect of the "On the Spot Firm"program on firm entry over time

Table 4: Competition and firm size

Dependent variable:	ln(sales)	ln(employment)	ln(output)
	(1)	(2)	(3)
OTSF reform	-0.038***	-0.035***	-0.066***
	(0.007)	(0.003)	(0.008)
Firm fixed effects	yes	yes	yes
Year fixed effects	yes	yes	yes
R^2	0.016	0.034	0.014
No. obs.	561,194	561,194	370,390

The *OTSF* variable is lagged one year. Other covariates include whether the firm is an exporter, whether multi-establishment, ownership, and age. Observations are at the firm-year level. Robust standard errors, clustered by municipality, are reported in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 5: Competition and the number of hierarchy layers

Dependent variable:	number of layers			
	OLS		Poisson	
	(1)	(2)	(3)	(4)
All firms				
OTSF reform	-0.124***	-0.100***	-0.051***	-0.041***
	(0.006)	(0.005)	(0.001)	(0.002)
R^2 / Log-likelihood	0.019	0.200	-642,102	-889,161
No. obs.	599,849	599,849	599,233	599,849
Layers pre-reform = 2				
OTSF reform	-0.019***	-0.007	-0.010***	-0.004
	(0.005)	(0.005)	(0.002)	(0.002)
R^2 / Log-likelihood	0.006	0.026	-358,709	-491,803
No. obs.	360,672	360,672	360,122	360,672
Layers pre-reform = 3				
OTSF reform	-0.251***	-0.248***	-0.092***	-0.090***
	(0.011)	(0.011)	(0.002)	(0.004)
R^2 / Log-likelihood	0.043	0.078	-184,555	-244,883
No. obs.	160,619	160,619	160,599	160,619
Layers pre-reform = 4				
OTSF reform	-0.342***	-0.342***	-0.094***	-0.094***
	(0.018)	(0.017)	(0.002)	(0.005)
R^2 / Log-likelihood	0.081	0.138	-98,010	-126,913
No. obs.	77,623	77,623	77,621	77,623

The *OTSF* variable is lagged one year. Observations are at the firm-year level. Odd-number columns include firm and year fixed effects and even-number columns include industry, municipality and year fixed effects. Other covariates include whether the firm is an exporter, whether it is multi-establishment, ownership, and age. Robust standard errors, clustered by municipality, are reported in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

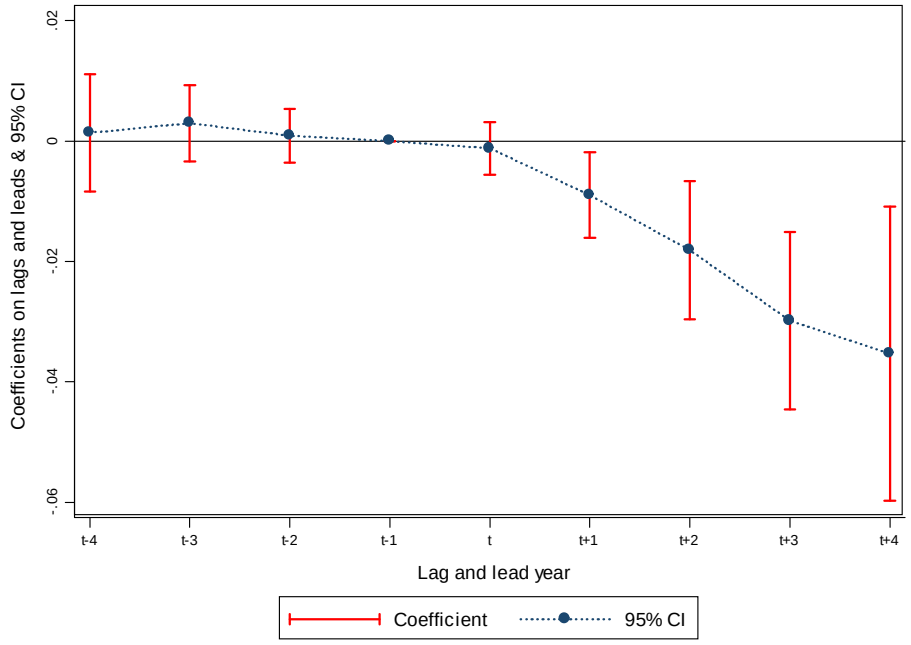

Figure 4: Effect of the "On the Spot Firm" program on the number of layers over time

Table 6: Competition and average span of control

Dependent variable:	average span of control					
Layer:	Top managers (Layer 3)		Middle managers (Layer 2)		Higher-skilled (Layer 1)	
	(1)	(2)	(3)	(4)	(5)	(6)
All firms						
$OTSF$ reform	0.005	0.055**	0.003	0.097**	0.049	0.305***
	(0.017)	(0.022)	(0.039)	(0.043)	(0.054)	(0.075)
R^2	0.000	0.038	0.002	0.050	0.005	0.135
No. obs.	400,330	400,330	222,401	222,401	223,245	223,245
Layers pre-reform = 2						
$OTSF$ reform	-0.310***	-0.233***	-0.240***	-0.057	-0.063	0.500***
	(0.026)	(0.030)	(0.048)	(0.051)	(0.056)	(0.089)
R^2	0.005	0.079	0.006	0.131	0.002	0.089
No. obs.	215,895	215,895	80,506	80,506	63,234	63,234
Layers pre-reform = 3						
$OTSF$ reform	0.383***	0.434***	-0.195***	-0.006	0.094	0.464***
	(0.047)	(0.050)	(0.069)	(0.079)	(0.058)	(0.102)
R^2	0.005	0.029	0.004	0.088	0.006	0.168
No. obs.	114,082	114,082	74,354	74,354	91,930	91,930
Layers pre-reform = 4						
$OTSF$ reform	0.275***	0.263***	0.436***	0.467***	0.041	0.020
	(0.050)	(0.048)	(0.079)	(0.080)	(0.116)	(0.132)
R^2	0.001	0.042	0.003	0.037	0.006	0.153
No. obs.	69,934	69,934	67,293	67,293	67,867	67,867

The dependent variable is the average span of control of each layer in the firm, defined as the number of employees in the layer below per employee in a layer, e.g. the span of control of top managers (layer 3) is the number of employees in the layer below per top manager. Observations are at the firm-year level. The $OTSF$ variable is lagged one year. Odd-number columns include firm and year fixed effects and even-number columns include industry, municipality and year fixed effects. Other covariates include whether the firm is an exporter, whether it is multi-establishment, ownership, and age. Robust standard errors, clustered by municipality, are reported in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 7: Competition and top-bottom-layer pay inequality

Dependent variable:	Top-bottom-layer pay ratio					
Sample of workers:	All workers			Stayers in the firm		
Sample of firms:	All firms	Drop layers	Same layers	All firms	Drop layers	Same layers
	(1)	(2)	(3)	(4)	(5)	(6)
OTSF reform	-0.060***	-0.153***	-0.005	-0.106***	-0.214***	-0.033
	(0.018)	(0.041)	(0.030)	(0.020)	(0.046)	(0.027)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.000	0.001	0.002	0.001	0.001	0.005
No. obs.	277,035	99,378	125,054	250,180	84,282	127,464

The dependent variable is the ratio of average hourly pay in the top layer in the firm to average pay in the bottom layer. Observations are at the firm-year level. The *OTSF* variable is lagged one year. All specifications control for firm and year fixed effects. Other covariates include whether the firm is an exporter, whether it is multi-establishment, ownership, and age. Columns (1) and (4) report results for all firms while columns (2) and (5) are for the sample of firms that drop layers after the *OTSF* reform, and columns (3) and (6) for those that have the same number of layers after the *OTSF* reform. Columns (4)-(6) report results for the sample of workers that remain in the same firm after the reform. Robust standard errors, clustered by municipality, are reported in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 8: Competition and pay inequality, alternative measures

Dependent variable:	std. dev. ln hr. pay	90-10 pay ratio	90-50 pay ratio	std. dev. ln hr. pay	90-10 pay ratio	90-50 pay ratio
Sample of workers:		All workers			Stayers in the firm	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: All firms						
OTSF reform	-0.013***	-0.068**	-0.032	-0.016***	-0.105***	-0.062***
	(0.001)	(0.033)	(0.022)	(0.002)	(0.031)	(0.022)
R^2	0.005	0.000	0.000	0.009	0.000	0.000
No. obs.	265,051	277,035	277,035	233,894	250,180	250,180
Panel B: Firms that drop layers after the OTSF reform						
OTSF reform	-0.023***	-0.141***	-0.074***	-0.028***	-0.238***	-0.139***
	(0.003)	(0.038)	(0.022)	(0.003)	(0.031)	(0.023)
R^2	0.008	0.000	0.000	0.011	0.001	0.000
No. obs.	90,861	99,378	99,378	74,377	84,282	84,282
Panel C: Firms that do not change the number of layers after the OTSF reform						
OTSF reform	-0.008***	-0.009	0.009	-0.009***	-0.018	-0.008
	(0.002)	(0.064)	(0.045)	(0.002)	(0.058)	(0.041)
R^2	0.008	0.001	0.001	0.012	0.001	0.001
No. obs.	122,480	125,054	125,054	122,040	127,464	127,464

The *OTSF* variable is lagged one year. All specifications control for firm and year fixed effects. Other covariates include whether the firm is an exporter, whether it is multi-establishment, ownership, and age. Observations are at the firm-year level. Columns (4)-(6) report results for the sample of workers that stay in the same firm after the reform. Robust standard errors, clustered by municipality, are reported in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 9: Competition and worker-level outcomes, firms that reduce the number of layers

Dependent variable:	Δln(wage)		Pr(promotion)		Pr(demotion)		Pr(exit)
Sample:	All		All	Stayers	All	Stayers	All
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$OTSF \times layer0_{pre\text{-}OTSF}$	0.018***	0.015***	0.022***	0.022***			0.047***
	(0.003)	(0.003)	(0.002)	(0.002)			(0.008)
$OTSF \times layer1_{pre\text{-}OTSF}$	0.001	-0.003	-0.056***	-0.058***	-0.059***	-0.058***	0.025***
	(0.005)	(0.004)	(0.005)	(0.006)	(0.005)	(0.005)	(0.009)
$OTSF \times layer2_{pre\text{-}OTSF}$	-0.001	-0.003	-0.063***	-0.065***	-0.070***	-0.074***	0.040***
	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.009)
$OTSF \times layer3_{pre\text{-}OTSF}$	0.003	-0.001			-0.013**	-0.013**	0.049***
	(0.006)	(0.004)			(0.006)	(0.006)	(0.007)
Worker-firm fixed effects	Yes						
Industry fixed effects		Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.004	0.004	0.033	0.033	0.021	0.021	0.050
No. obs.	759,463	759,463	758,233	681,358	361,613	332,345	886,117

Observations are at the worker-year level. The $OTSF$ variable is lagged one year. $layerl_{pre\text{-}reform}$ is an indicator variable for the hierarchy layer of the worker in the year prior to the reform. The regressions consider all post-reform years and three pre-reform years. Pr(exit) takes the value of one if the worker is in the firm for the last time in the current period. Demotion (promotion) is defined as a lower (higher) layer than in the previous period. The probability of demotion is conditional on starting from at least occupational layer 1 and the probability of promotion is conditional on starting in up to occupational layer 2. Other covariates include, at the worker-level: tenure and its square, education, type of contract of employment; and at the firm-level: whether the firm is an exporter, whether it is multi-establishment, ownership, and age. All regresions also include indicators for the workers' layer in the year prior to the reform. The regressions for exit, promotion and demotion are linear probability models. Robust standard errors, clustered by municipality, in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 10: Alternative mechanisms

Panel A					
Dependent variable:	New products		New export	Outsourcing	
	HS6 exported	PC6 produced	countries	imp/material	purch/sales
	(1)	(2)	(3)	(4)	(5)
$OTSF$ reform	-0.016	-0.019*	0.006	0.003	0.003
	(0.020)	(0.011)	(0.011)	(0.004)	(0.004)
R^2	0.008	0.280	0.007	0.229	0.100
No. obs.	29,856	27,378	29,856	24,775	196,434
Panel B					
Dependent variable:	Investment	Information technology use			
	in R&D	email	intranet	extranet	
$OTSF$ reform	-0.019	-0.001	-0.020	-0.027	
	(0.021)	(0.003)	(0.020)	(0.019)	
		0.010	0.031	0.041	
R^2	0.003	0.010	0.031	0.041	
No. obs.	202,300	17,096	16,598	16,345	

Observations are by firm-year. The $OTSF$ variable is lagged one year. All specifications control for firm and year fixed effects. Other covariates include whether the firm is an exporter, whether it is multi-establishment, ownership, and age. Robust standard errors, clustered by municipality are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

A Appendix

Table A.1: Summary statistics

Variables	All firms (1)	Pre-reform number of layers: 2 layers (2)	3 layers (3)	4 layers (4)
ln(real sales)	12.771	12.185	13.194	14.641
ln(employment)	1.997	1.562	2.287	3.424
ln(real output)	5.592	4.914	5.981	7.626
ln(hourly pay)	1.219	1.159	1.278	1.364
Number of layers	2.410	1.997	2.746	3.642
Span of control (emp. layer below/emp. layer)				
Layer 3	2.225	2.263	2.115	2.286
Layer 2	3.515	3.286	3.808	3.465
Layer 1	4.839	3.531	4.575	6.418
Top-bottom-layer hourly pay ratio	2.003	1.525	2.091	3.109
Top-bottom-layer schooling ratio	1.280	1.157	1.307	1.559
Top-bottom-layer experience ratio	1.334	1.360	1.370	1.219
Standard deviation of ln(hourly pay)	2.441	1.590	2.604	4.237
90-10 hourly pay ratio	2.296	1.906	2.548	2.946
90-50 hourly pay ratio	1.681	1.489	1.806	2.000
OTSF reform	0.434	0.435	0.434	0.433
New firm creation	2.427			

Own calculations based on Portugal's linked employer-employee data (LEED) from the Ministry of Labor and Social Solidarity (MTSS), 2002-2009. The table reports averages of the variables, and were computed using the stimation sample.

Table A.2: Competition, delayering and pay inequality

Dependent variable:	top-bottom pay ratio (1)	std. dev. ln(hr. pay) (3)	90-10 pay ratio (4)	90-50 pay ratio (5)	50-10 pay ratio (6)
$OTSF$ reform	0.073***	-0.001	0.047	0.037	-0.003
	(0.026)	(0.001)	(0.044)	(0.030)	(0.003)
$OTSF$ reform × drop	-0.331***	-0.033***	-0.287***	-0.171***	-0.045***
	(0.052)	(0.001)	(0.052)	(0.033)	(0.004)
R^2	0.001	0.008	0.000	0.000	0.002
No. obs.	277,035	265,051	277,035	277,035	277,035

The $OTSF$ variable is lagged one year. *drop* is a dummy variable that takes the value 1 if the firm reduces the number of layers after the reform and zero otherwise. All specifications control for firm and year fixed effects. Other covariates include whether the firm is an exporter, whether it is multi-establishment, ownership, and age. Observations are at the firm-year level. Robust standard errors, clustered by municipality, are reported in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table A.3: Competition, firm hierarchy and pay inequality

Sample of firms:	drop top layer	drop middle layer	drop bottom layer
	(2)	(3)	(4)
Panel A - dependent variable: Top-bottom pay ratio			
$OTSF$ reform	-0.137***	-0.117**	-0.129***
	(0.024)	(0.048)	(0.041)
R^2	0.003	0.002	0.006
No. obs.	89,910	28,929	30,184
Panel B - dependent variable: 90-10 pay ratio			
$OTSF$ reform	-0.133***	-0.067	-0.322***
	(0.036)	(0.118)	(0.086)
R^2	0.000	0.000	0.001
No. obs.	89,910	28,929	30,184
Panel C - dependent variable: 90-50 pay ratio			
$OTSF$ reform	-0.060***	-0.045	-0.128***
	(0.017)	(0.052)	(0.030)
R^2	0.001	0.000	0.002
No. obs.	89,910	28,929	30,184

Observations are at the firm-year level. The $OTSF$ variable is lagged one year. All specifications control for firm and year fixed effects. Other covariates include whether the firm is an exporter, whether it is multi-establishment, ownership, and age. Robust standard errors, clustered by municipality, are reported in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table A.4: Competition and top-bottom-layer knowledge

Sample of workers:	All workers			Stayers		
Sample of firms:	All firms	Drop layers	Same layers	All firms	Drop layers	Same layers
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A - dependent variable: education ratio						
$OTSF$ reform	-0.031***	-0.039***	-0.031***	-0.044***	-0.062***	-0.030***
	(0.004)	(0.005)	(0.004)	(0.004)	(0.006)	(0.004)
R^2	0.002	0.013	0.004	0.007	0.017	0.016
No. obs.	274,945	96,872	125,703	248,845	81,860	128,250
Panel B - dependent variable: experience ratio						
$OTSF$ reform	-0.048***	-0.090***	-0.013	-0.088***	-0.125***	-0.059***
	(0.007)	(0.013)	(0.009)	(0.007)	(0.013)	(0.008)
R^2	0.002	0.007	0.001	0.009	0.019	0.004
No. obs.	274,929	96,866	125,698	248,825	81,854	128,237

The dependent variable is the ratio of average number of years of schooling in the top layer in the firm to the average in the bottom layer in Panel A and the top-bottom layer experience ratio in Panel B. Experience is potential labour market experience (computed as age minus the number of years of education minus 6). Observations are at the firm-year level. The $OTSF$ variable is lagged one year. All specifications control for firm and year fixed effects. Other covariates include whether the firm is an exporter, whether it is multi-establishment, ownership, and age. Robust standard errors, clustered by municipality, are reported in parentheses. * $p<0.10$; ** $p<0.05$; *** $p<0.01$.