Internal Organization of Firms and Minimum Wage Spillovers†

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Preliminary Draft

February 28, 2025

Abstract

This paper provides empirical evidence that firms' internal organization and associated pay policies shape the propagation of minimum wage spillovers. Rigid, tournament-like firms use between-tier pay differentials to incentivize workers and respond to minimum wage hikes by raising wages up the hierarchy, amplifying spillovers. Flexible firms that rely more on individualized wage-setting can limit spillovers. I highlight these mechanisms in a simple model of firm organization and pay policies. Empirically, I leverage rich administrative employer-employee data from Portugal to construct measures of firm rigidity and examine how organizational structure shapes the strength of spillovers. Studying two minimum wage hikes, I find that spillovers from the minimum wage reach the 47^{th} percentile of the wage distribution and represent around 40% of the direct effect on minimum wage workers. I show that spillovers are up to 40% stronger in rigid firms, with well-defined hierarchies and structured pay policies. These findings have broader implications for a wide range of shocks that shift relative pay within firms.

JEL Classification: J31; J38; J41; L22

†I am grateful for helpful discussions with Charles Brown, Pierre Cahuc, Decio Coviello, Thomas F. Crossley, Alexander Hijzen, Andrea Ichino, Fabian Lange, Claire Montialoux, and Till von Wachter. I also thank seminar participants at the European University Institute, HEC Montréal, McGill University, the OECD, and Sciences Po for useful comments. Funding from *Fundação para a Ciência e a Tecnologia* (SFRH/BD/150666/2020) and the Portuguese DG for European Affairs (Bolsa Mário Soares) are gratefully acknowledged, as is data access by Statistics Portugal (*Instituto Nacional de Estatística*).
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1 Introduction

The minimum wage imposes a shock on firms' labor costs. The effects are known to propagate beyond directly affected workers, increasing wages above the minimum and amplifying the shock (Grossman, 1983; Lee, 1999; Cengiz, Dube, Lindner, & Zipperer, 2019). Minimum wage spillovers are well documented, but less is known about the firm-level factors that determine their reach and magnitude.

In this paper, I study how a firm's internal organization affects the propagation of such shocks. I focus on a particularly understudied aspect of the firm's structure: organizational rigidity. *Rigid* firms have well-defined hierarchies, pay is defined by the job title, and wage increases occur primarily through promotions, in a tournament-like structure. In *flexible* firms, wages are largely individual-specific, as performance pay and individual bargaining assume more prominent roles. In rigid, tournament-like firms, preserving pay differentials between tiers is key to incentivize workers. Since wages are tied to job titles, adjustments impact all workers within a category. These features amplify spillovers. In flexible firms, individual-level spillovers may still arise, but broad, tier-based adjustments play a much smaller role.

Specifically, I ask whether a firm's rigidity helps explain minimum wage spillovers. I construct empirical measures of firm rigidity to study its impact on the propagation of spillovers. The question of how internal organization shapes the propagation of shocks is relevant for a wide range of shocks that shift relative pay within firms. Among these, the minimum wage is a particularly suitable case-study. First, it raises labor costs for all firms regardless of their internal structure. Second, it is of clear policy relevance. Finally, minimum wage spillovers provide a natural measure of shock propagation.

To set the stage, I develop a simple theoretical model that highlights the mechanisms linking firm rigidity to the extent of spillovers. I study the introduction of a minimum wage under two organizational structures and associated pay policies: a rigid, tournament-like firm (E. P. Lazear & Rosen, 1981); and a flexible, performance pay firm. Tournament firms set job title-specific wages, and the spread between different rungs of the job ladder is the key incentive mechanism. Workers exert effort to secure promotions and corresponding pay raises. A binding minimum wage compresses the between-rung wage spread, inducing an effort reduction. To revamp effort levels and sustain productivity, firms increase the wage in higher rungs, generating spillovers. Differently, flexible firms set individual wages through a combination of base pay and performance rate, used to incentivize effort. As the minimum wage increases base pay, firms must cut performance rates to balance costs. Two forces mitigate spillovers in flexible firms: a direct effect through the cut in performance rate, and an indirect effect resulting from a reduction in effort leading to lower productivity and therefore pay. The model thus predicts stronger spillovers in firms with rigid structures and tournament-like pay policies.

The empirical analysis focuses on Portugal during 2012–2016, which provides an ideal setting for two reasons. First, the period covers two minimum wage hikes, each preceded by two consecutive years of constant minimum wage. This context is well-suited to identify the causal effects of the minimum wage along the wage distribution, including spillovers. Second, administrative employer-employee data (*Quadros de Pessoal*, QP) provide rich and granular information on occupations, hierarchical positions, job titles, and wages, offering a clear view of workforce organization and the evolution of wages.

I begin by estimating the causal effect of the minimum wage on the wages of workers who are not directly affected by the policy – spillovers. The empirical strategy examines heterogeneous wage growth responses to the policy along the wage distribution. This design follows a well-established tradition in the minimum wage literature. The formulation closely follows Dustmann, Lindner, Schönberg, Umkehrer, and vom Berge (2022), with the key distinction that my focus lies on spillovers rather than direct effects.[1] Wage growth during hike periods is compared to growth on a prior period of constant minimum wage, controlling for workers' position in the distribution and baseline characteristics. Additionally, I benchmark spillover workers against those further up the distribution and unaffected by the policy. In doing so, I address key threats to causal interpretation related to mean reversion in earnings of low-wage workers (Ashenfelter & Card, 1982) and potential confounding from macroeconomic conditions.

Spillovers arise endogenously from wage-setting responses rather than as direct policy effects. To examine how firm rigidity shapes these responses, I leverage the detail in the data to construct two complementary measures. The first captures the number of unique pay points per worker at the firm – $PayPoints$. The second – $Disp^{jt}$ – measures wage dispersion within job titles, a job category combining task-content with a hierarchical component. This granularity ensures that the measures reflect internal rigidity rather than differences in firm size or overall wage dispersion in the firm. In rigid firms, wages are primarily determined by job titles and there is a limited role for individual compo-

[1] See e.g. Currie and Fallick (1996) and Dube (2019). For rich methodological surveys in the UK context, see Stewart (2004) and Brewer, Crossley, and Zilio (2019).

nents, making the tournament mechanism the dominant incentive structure. These firms exhibit fewer unique pay points per worker and lower within-title wage dispersion. In contrast, flexible firms rely on individual wage-setting, displaying a greater number of distinct pay points and higher within-title variance. In the final step of the analysis, I use these measures to assess how rigidity shapes the extent of spillovers.

I provide robust evidence of spillover effects from the minimum wage. Minimum wage hikes raise wages of directly affected workers, but also cause additional wage growth for those initially earning above the new minimum wage. The magnitude of spillovers is large, with post-hike average wage growth around 1% higher than pre-hike for affected workers, corresponding to a 35% increase over baseline and around 40% of the direct effect on minimum wage workers. Spillovers are strongest up until the 25^{th} percentile (*strong spillover region*), but extend significantly further, with detectable effects up to the 47^{th} percentile (*pervasive spillover region*). These effects are not explained by changing macroeconomic conditions. First, there are no effects for higher-wage workers. Second, the findings hold across two hikes occurring in different economic environments.

The main results strongly supports that within-firm structure and associated pay policies influence spillover strength. First, consistent with the notion that spillovers arise from within-firm adjustments, I find stronger spillovers in firms where the minimum wage binds. In the case of rigid firms, directly raising higher wages is key to maintaining incentives only if minimum wages bind. In flexible firms, non-binding minimum wages require no pay-schedule adjustments. Second, I find significantly stronger spillovers in rigid firms, with tournament-like pay policies. I examine how the spread of the labor cost shock depends on firms' pre-shock rigidity, finding that rigid firms generate up to 40% larger spillovers. Consistent with a tournament structure where job titles define wages and there is little room for individual bargaining over raises, rigid firms exhibit lower baseline wage growth. The stronger spillover effect in rigid firms offsets 40–80% of the baseline wage growth gap, depending on the rigidity measure.

I show that these results are driven by firms' rigidity rather than alternative correlated characteristics. The result that stronger spillovers arise in rigid firms holds across different definitions of spillover region, two rigidity measures, and is not driven by size- or sector-specific responses to the minimum wage. The effect remains robust when controlling for the firm-level minimum wage bite at baseline and exposure-driven policy reactions, ruling out explanations linked to differences in minimum wage exposure across organizational structures. The results persist even after excluding small firms, where rigidity measures may be confounded by size and job title composition, and where the tournament mechanism is plausibly less relevant. Finally, accounting for differences in workforce skill composition in rigid *vs* flexible firms has no effect on the results, alleviating concerns that job title wage dispersion reflects skill differences rather than pay policy and wage structure.

Related Literature This study contributes to three related strands of the literature. Firm organization is a central topic in personnel economics.[2] Part of this literature examines the optimal number and size of hierarchical layers (Gumpert, Steimer, & Antoni, 2021; Chen, 2017; Chen & Suen, 2019), or management practices (Bloom, Sadun, & Van Reenen, 2012; Bloom & Van Reenen, 2010). This paper relates most closely to theories of organization and pay Garicano (2000); Garicano and Rossi-Hansberg (2006, 2004); E. P. Lazear and Rosen (1981); Rosen (1982, 1986), their empirical applications (E. P. Lazear, 2000; Goldin, 1986; Brown, 1990; Coviello, Deserranno, & Persico, 2022; Deserranno, Caria, Kastrau, & León-Ciliotta, 2024), and the real effects of administrative pay systems (Gibbs & Hendricks, 2004). I contribute by providing empirical evidence that highlights the importance of an understudied dimension, rigidity, and its links to the tournament mechanism. I construct rigidity measures that integrate task content and hierarchy, capturing firms' reliance on structured pay policies. Despite its recognized importance (E. Lazear & Shaw, 2007, 2009; Shaw, 2014), this aspect has received limited empirical attention, with notable exceptions in Giupponi and Machin (2022) and Machin and Datta (2024).

This article also contributes to the literature on minimum wage spillovers (Katz & Krueger, 1992; Neumark, Schweitzer, & Wascher, 2004; Neumark & Wascher, 2008; Cengiz et al., 2019; Dube, Giuliano, & Leonard, 2019; Giupponi et al., 2024), established since Grossman (1983) and Lee (1999). I focus on the smaller but growing strand examining spillover mechanisms (Lordan & Neumark, 2018; Aaronson & Phelan, n.d.; Phelan, 2019; Gregory & Zierahn, 2022). Previous studies mostly focus on substitution effects. I provide, to my knowledge, the first robust evidence that, consistent with the tournament mechanism, firms with rigid structures generate stronger spillovers. Closest to my work, Forsythe (2023) finds that supervision structures drive spillovers in U.S. firms, as only supervisors display spillover-consistent wage growth. In contrast, I find similar effects among both supervisors and non-supervisors, suggesting an important role for a complementary mechanism. Giupponi and Machin (2022) show that fairness concerns drive

[2] For a complete overview, see E. Lazear and Shaw (2007).

spillovers in the UK's social care sector, affecting workers excluded from the policy. This paper complements their work by examining how firm's organization and pay policies shape spillovers along the wage distribution, rather than to explicitly unaffected groups of workers.

Finally, this paper adds to the growing research on the interaction between firm organization and shocks. Prior work focuses on how firms adjust their structure to demand, productivity, or trade shocks (Friedrich, 2022; Caliendo, Monte, & Rossi-Hansberg, 2015; Gumpert et al., 2021; Caliendo, Mion, Opromolla, & Rossi-Hansberg, 2020), or organizational changes affect productivity, labor demand, and wages (e.g. Caroli and Van Reenen (2001)). I shift the focus from how firms reorganize in response to shocks to how organization shapes the propagation of shocks within firms. Specifically, I show that rigidity amplifies minimum wage spillovers, as hierarchy and pay structures constrain how firms absorb wage shocks. While I use minimum wage hikes as an exogenous labor cost shock, the findings have broader implications: any shock affecting relative pay within firms will propagate more strongly in rigid organizations, where hierarchy is well defined and the tournament mechanism plays a larger role.

Roadmap The paper proceeds as follows. Section 2 presents a model highlighting the theoretical mechanisms linking firm organization and pay policies to minimum wage spillovers. Section 3 describes the Portuguese wage-setting environment and the data. In Section 4, I discuss the empirical strategy to estimate spillovers and provide evidence of their importance. Section 5 discusses the measures of firms' internal organization and pay policy. Section 6 discusses the core results of the paper, before the final section concludes.

2 A Simple Model for Firm-Level Spillovers

This section provides a simple theoretical framework highlighting the mechanisms linking the organizational structure of firms and associated pay policies to the propagation of minimum wage spillovers.

Consider a risk-neutral firm which employs two workers $i = j, k$ at a wages w_i and sells the production output $Q = \sum_i q_i$ in the market at unit price p, with profit:

$$\Pi = p \sum_i q_i - \sum_i w_i$$

There is free entry and competition for labor. All else equal, firms want to maximize output and revenue, which they achieve by incentivizing workers.

Risk-neutral workers exert costly effort ei to produce q_i according to:

$$q_i = e_i + \eta_i, \quad \eta \overset{i.i.d.}{\sim} f(0, \sigma^2), \quad \forall \quad i = j, k;$$

where η_i is a mean 0 productivity shock. The cost of effort is described by a common function $C(e)$, with $C' > 0, C'' > 0$. Workers earn unemployment benefits U_0 if they don't work.

The firm cannot observe effort, and commits to a pay policy (labor contract) contingent on observable output.[3] Workers learn the contract, choose effort to maximize expected utility, and produce. Finally, the firm sells the output and pays wages.

I derive the baseline equilibrium under alternative pay policies: tournaments and performance pay. Then, I introduce a minimum wage and study the emergence of spillovers in each case.

Tournaments

I start from the seminal tournaments model in E. P. Lazear and Rosen (1981). Workers are initially employed in the same entry-level job, earning W_0 ($> U_0$ by assumption). At the end of the period, the firm promotes the most productive worker (higher q) to the next layer in its hierarchy, paying her the $W_1 > W_0$ wage associated with the new position. The equilibrium concept in the tournament between workers is Nash-Cournot. Given the set of wages (W_0, W_1), each worker solves their problem taking as given the opponent's

[3] We assume the firm's choice of contract is exogenous, part of its and pre-determined operational technology. Why firms choose different pay policies is beyond the scope of this project, and an interesting avenue for future research.

best response. The firm internalizes workers' decisions and sets the optimal (W_0, W_1).

The workers trade-off the benefit of additional effort, materialized through increased probability of promotion, against its the additional cost. Their expected utility is:

$$EU = PW_1 + (1-P)W_0 - C(e)$$

where P is the endogenous probability of promotion. For worker j, it is given by

$$P = P(q_j > q_k) = P(e_j - e_k > \eta_k - \eta_j) = G(e_j - e_k)$$

where $\xi = \eta_k - \eta_j \sim g(0, 2\sigma^2)$ from $i.i.d.$ of η, and G is the CDF associated with g. Under the symmetric Nash equilibrium ($e_j^* = e_k^*$), worker optimality is given by:

$$C'(e_i) = (W_1 - W_0)g(0), \quad \forall i = j, k \tag{1}$$

Competition for labor bids up the wages until the firm makes zero expected profits. Using the equilibrium $q_j^* = q_k^*$:

$$pe = \frac{(W_1 + W_0)}{2} \tag{2}$$

The equilibrium wage structure maximizes workers' EU at the optimal effort. Symmetry implies $P = 1/2$. Combining the firm's no profit condition with the workers' equilibrium EU, taking the F.O.C., and combining with (1) yields:

$$pe - C(e) \longrightarrow p = (W_1 - W_0)g(0) \tag{3}$$

The above conditions define the equilibrium $(e^*, W_0^*.W_1^*)$, systematized by $(T.1$ - $T.3)$ as:

$$\begin{cases} C'(e^*) = (W_1^* - W_0^*)g(0) & (T.1) \\ W_0^* = pe^* - \frac{p}{2g(0)} & (T.2) \\ W_1^* = pe^* + \frac{p}{2g(0)} & (T.3) \end{cases}$$

Flexible Wage Schedule: Performance Pay

Under the canonical performance pay contracts (E. P. Lazear & Gibbs, 2009; Kuhn, 2018), the firm pays each worker individually according to a flexible schedule of the form:

$$w_i = a + bq_i$$

where $a \geq 0$ is the base pay and b is the piece-rate. Workers expected utility is:

$$EU = \mathbb{E}\{a + b(e_i + \eta_i) - C(e_i)\} = a + be_i - C(e_i)$$

Worker optimality $(P.1)$, profit maximization under market competition $(P.2)$, and the participation constraint $(P.3)$ determine the equilibrium (e^*, a^*, b^*):

$$\begin{cases} b = C'(e^*) & (P.1) \\ pe^* = a + be^* & (P.2) \\ a + be^* \geq U_0 & (P.3) \end{cases}$$

2.1 A Binding Minimum Wage

I now study the introduction of a binding minimum wage. The policy exogenously determines one of the variables. Finding the new equilibrium amounts to solving the remaining system of two equations.

Tournaments

This simple formulation in equation (1) captures the main mechanisms of interest. The optimal level of effort is determined by the spread between current and promotion wages. Any shock affecting this spread changes the incentive structure. A binding minimum wage increases the baseline wage, reduces the spread, consequently lowering optimal effort and output. To revamp effort levels, firms have an incentive to increase the promotion wage, generating spillovers.

In the tournament setting, a binding minimum wage implies $MW > W_0$. The equilibrium system becomes:

$$\begin{cases} C'(e^{MW*}) = (W_1^{MW*} - MW)g(0) & (T.1^{MW}) \\ W_0^{MW*} = max\{pe^{MW*} - \frac{p}{2g(0)}, MW\} = MW & (T.2^{MW} : \textit{binding MW}) \\ W_1^{MW*} = pe^{MW*} + \frac{p}{2g(0)} & (T.3^{MW}) \end{cases}$$

Comparing conditions $(T.1)$ and $(T.1^{MW})$ in combination with the optimal determination of (W_0, W_1) in each case:

$$\frac{C'(e^*)}{pe^* + \frac{p}{2g(0)} - W_0} = g(0) \qquad \& \qquad \frac{C'(e^{MW*})}{pe^{MW*} + \frac{p}{2g(0)} - MW} = g(0) \quad \rightarrow \quad e^{MW*} > e^*$$

implying

$$W_1^{MW*} = pe^{MW*} + \frac{p}{2g(0)} > W_1^* \qquad \text{(MW Spillovers)}$$

Upon the introduction of a binding $MW > W_0$, firm and workers re-optimization results in an increased promotion wage with respect to baseline.[4] In other words, the labor cost shock induced by the minimum wage spreads within the rigid organization through the optimal adjustments of agents: spillovers arise endogenously. A second result is that the increase in promotion wage induces an increase in effort for workers at the minimum wage. This theoretical result is consistent with recent evidence that minimum wage policies can increase individual productivity, particularly that of workers supported by the minimum wage Coviello et al. (2022).

Performance Pay

Under the performance pay policy, the minimum wage implies that $a^{MW} = MW > a^*$. No firm can set $a^{MW} < MW$, as workers would still earn MW for 0 effort. Firms won't pay $a^{MW} > MW$ either, as that would imply an excessive labor cost that is not effort-inducing. Since $a^{MW} > a^*$, firms have to decrease b to avoid incurring an expected loss (were operating at 0 profit). The new equilibrium implies higher a and lower b. Under performance pay, lower b induces a reduction in effort and output. Firms still make 0 profits in the new equilibrium, described by:

$$\begin{cases} b^{MW*} = C'(e^{MW*}) & (P.1^{MW}) \\ pe^{MW*} = a^{MW*} + b^{MW*}e^{MW*} & (P.2^{MW}) \\ a^{MW*} = MW > U_0 & (P.3^{MW} : \textit{binding MW}) \end{cases}$$

All firms or job titles with high enough base wage $a^{MW} < a^*$ are not affected by the policy. The minimum wage doesn't bind and there is be no impact on the wage schedule. This force limits the spread of spillovers. To assess the wage effects of the minimum wage on affected workers, I compare the two equilibrium wages: baseline (b) and minimum wage (mw).

$$\begin{aligned} \Delta W = w_{mw} - w_b &= (a^{MW*} - a^*) + (b^{MW*}e^{MW*} - b^*e^*) \\ &= (a^{MW*} - a^*) + b^*(e^{MW*} - e^*) + e^{MW*}(b^{MW*} - b^*) \end{aligned} \tag{4}$$

The minimum wage, through increased base pay, has a direct positive effect on wages. Equation (4) highlights the two forces that counteract that effect, muting spillovers under

[4] This requires parametric assumptions on the convexity of cost function and the product market price. It holds when the price is high relative to the cost function convexity ($C'' < g(0)p$ is a sufficient condition). I maintain this assumption throughout.

performance pay. First, in order to avoid a loss, the firms respond to increased base pay by flattening the productivity-pay slope. This decreases overall pay for a given quantity, all else constant, and is illustrated by the second term in equation (4). Second, the reduced piece rate shifts incentives for workers, who reduce effort, and therefore output, decreasing wages. This is the last term in the equation.

Under performance pay, increases in the minimum wage are counteracted by reductions in effort and piece-rates. These dampening forces that always reduce spillovers may even fully offset the direct effect for small minimum wage increases (we study MW increases of 5%) and for workers producing sufficiently high quantities, implying muted spillovers both in magnitude and reach over the distribution. Dampening forces completely offset spillovers if $|b^*(e^{MW*} - e^*) + e^{MW*}(b^{MW*} - b^*)| \geq (a^{MW*} - a^*)$.

2.2 Testable Implications

The model shows how minimum wage hikes produce comparatively stronger spillovers in tournament-like, rigid firms than in flexible, performance-pay ones. Below, I summarize the main testable implications (TI) to guide the empirical work.

TI 1 *Spillovers are stronger when the minimum wage binds at the firm.*

Spillovers arise only if the minimum wage bites at the firm level. In the case of tournaments, spillovers arise as a response to the compression in the spread between base and promotion wages. If the minimum wage does not bind, the equilibrium effort and wage structure do not change, and no within-firm re-optimization takes place. In the performance pay setting, if base pay was already higher than the new minimum wage, no incentives shift and no spillovers materialize. In both cases, the firm only adjusts its pay schedule when the minimum wage binds. If the model provides a relevant explanation for minimum wage spillovers, they should be stronger in firms with higher shares of minimum wage employment. In the empirical section, we test if this is the case.

In practice, firms for which the minimum wage does not bind may also experience spillovers. The model abstains from general equilibrium considerations, but market interaction effects such as labor substitution (Phelan, 2019), fairness concerns, or last-place aversion (Kuziemko, Buell, Reich, & Norton, 2014) can rationalize that result.

TI 2 *Spillovers are stronger in firms with rigid, tournament-like organizational structures.*

In the model, spillovers in firms with tournament pay-policies arise from firms wanting to preserve the incentive structure, which crucially depends on the spread between current and promotion wages. This feature is most characteristic of firms with rigid organization structures, where pay is largely defined independently from individual workers, and wage tiers and internal career progression are well-defined. The model shows that, in tournament firms, the wage is job title-specific and there is no within-job wage dispersion.

In firms with performance pay policies, the wage setting is more flexible and individual workers have larger importance. Wages are not fully tier-specific and the spread between the wages at different tiers is not the incentive mechanism. Since wages are individual-specific, there is within-job title wage dispersion.[5] Upon a minimum wage hike, adjustments on the base and piece components may still lead to spillovers in flexible firms, but the incentive for the firm to incur in the generalized wage increase for higher tiers is non-existent. The minimum wage increase flattens the effort-return profile, causing a downward pressure on output and wages, reducing the strength of spillovers.

In firms with rigid structures and tournament-like pay policies, firms have an unambiguous incentive to increase higher wages for all workers. In flexible firms, spillovers may arise for some workers earning close to the minimum wage, but in reduced magnitude due to the dampening force, particularly for small minimum wage hikes. For those reasons, I expect stronger spillovers in rigid firms.

3 Institutional Setting

3.1 Wage Bargaining Environment and Key Concepts

The wage bargaining system in Portugal is characterized by the relations between sectoral employer associations and trade unions, a feature broadly common to several European countries (Schulten, 2016). These parties negotiate collective bargaining agreements (CBAs) that set wage floors and general working conditions. While CBAs only formally bind firms and workers affiliated with the respective employer association and unions, their terms are frequently extended to the entire sector through government ordinances (*Portaria de Extensão*) (Naumann, 2018). As a result, despite formal unionization rates

[5]In this simple model, the dispersion is generated by different productivity shocks, but can also be rationalized by different extent of individual bargaining, for example (say, individual specific b_i).

of about 10%, CBAs cover around 90% of the workforce (Addison, Portugal, & Vilares, 2023). This widespread coverage ensures that differences in firms' organizational structures are not driven by different union influence, which is key for this paper's context.

Three key concepts underlie the structure of CBAs and how the institutional environment shapes wage-setting: *job title*, *wage floor*, and *wage cushion*.

Job Title is an occupational category *(Categoria Profissional)* within each CBA, defined as a combination of occupation, with the associated set of tasks, and seniority. They reflect required skills and internal rank of workers. For instance, accountants with different ranks (e.g., rank 1 *vs* rank 3) have distinct job titles, even if their core occupation is the same. Within CBAs, wage floors are negotiated at the job title level.

Wage Floor is the job title-specific minimum wage, a key outcome of collective bargaining. Each CBA explicitly defines these floors in a table listing job titles and corresponding minimum wages. For example, in 2019, an accountant of rank 3 had a wage floor of €950, while an accountant of rank 1 had a wage floor of €805. Figure A.1 in Appendix A provides a snippet from a CBA table published by the Ministry of Labor.[6] While the government sets the national minimum wage, CBAs define a much finer structure — QP data from a typical year includes around 30 000 job titles, translating to approximately 5 000 binding wage floors once duplications and classification mismatches are accounted for (Martins, 2021; Card & Cardoso, 2022).

Wage Cushion represents a premium that firms can, and often do, pay above the wage floor (Cardoso & Portugal, 2005; Card & Cardoso, 2022). Wage cushions vary by firm and worker and reflect differences in firm rigidity and wage-setting flexibility: flexible firm allow more relevant role for this component, while rigid ones less so, relying on job titles to set wages.

This wage setting environment can be formalized through a simple additive three-component model, adapted from Card and Cardoso (2022). Let W_{ijt} denote the regular monthly take home wage of worker i, job title j, and year t, excluding overtime compensation and bonuses. Its log counterpart w_{ijt}, useful to study wage growth, can be expressed as:

$$\begin{gathered} w_{ijt} = mw_t + f_{jt} + c_{it}, \\ \textit{with} \quad mw_t \equiv \ln MW_t, \quad f_{jt} \equiv \ln \frac{F_{jt}}{MW_t}, \quad c_{it} \equiv \ln \frac{W_{ijt}}{F_{jt}}. \end{gathered} \tag{5}$$

[6] CCT signed between AECOPS, AICCOPN, and AICE (employer associations) and FETESE, FE, and SINDEL (trade unions). BTE 26, 15/07/2017, with updates of July 2019. See here.

where the first component mw_t is the log national minimum wage (MW_t), annually set by the central government after consultation with the social partners. It applies uniformly to all firms and workers. The second component, f_{jt}, is the log collectively bargained wage floor (F_{jt}) for job title j, defined relative to the national minimum wage. Finally, c_{it} is the log wage cushion, the wage premium individually bargained by the worker over the wage floor.

A key distinction from Card and Cardoso (2012) is that this framework does not explicitly separate regular supplements, accounting them in the wage cushion. Consequently, the four-component model in Card and Cardoso (2012) simplifies to three components here.[7] Note that the distinction between rigid and flexible firm organizations is related to the within-firm variation in wages and wage cushions, not levels. As such, the arguments in the paper are not affected by this choice.

3.2 The National Minimum Wage

This paper examines firm-level responses to the labor cost shock induced by minimum wage hikes. The Portuguese labor code (*Código do Trabalho*) mandates that the national monthly minimum wage should account for increases in the cost of living and productivity. Its level is determined annually by the central government, following consultation with the Social Concertation Committee — a tripartite institution comprising the government, trade unions, and employer representatives from industrial associations.

While many European countries have only recently introduced or continue to debate minimum wages, Portugal has a long-standing tradition in this regard. The introduction of a national minimum wage dates back to May 1974, following the Carnation Revolution of April 25$^{\text{th}}$. It was set at 3,300 Portuguese *Escudos* (approximately 16€ at 2001 prices). Since then, it has been updated almost yearly, with around 45 revisions.

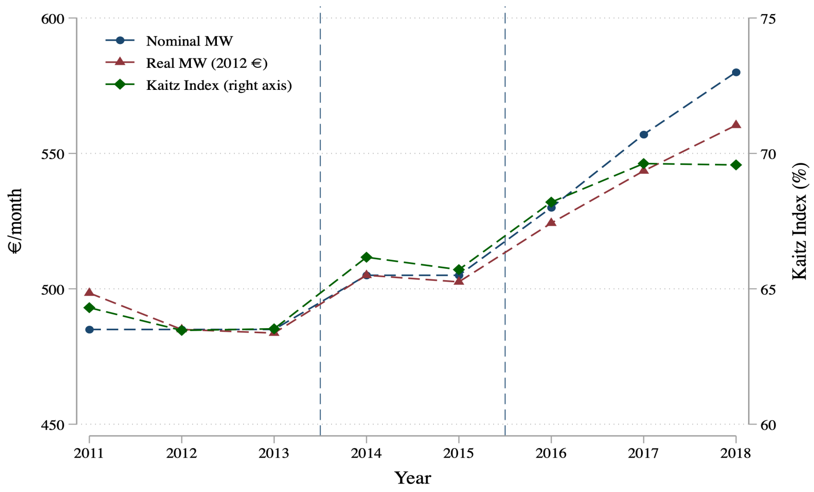
An exception occurred during the 2011–2014 Economic Adjustment Program negotiated with the *Troika* (ECB, IMF, and European Commission). Under the program, the minimum wage remained unchanged from 2011 until September 2014. Subsequent updates resumed in 2016, and continued on an annual basis. As a result, during the QP data collection period, the national minimum wage was stable in 2011–2013 and 2014–2015.[8]

[7] Some regular supplements result from union negotiations but their classification as part of the wage floor or cushion remains ambiguous.

[8] Each year, the Ministry for Employment collects data for October. In 2014, the updated minimum wage was already in effect.

This institutional feature is instrumental for the identification of wage effects of minimum wage hikes, including spillovers (see Section 4).

Figure 1: Minimum Wage Evolution



Notes: Evolution of the Minimum Wage over 2011-2019. Blue circles represent the nominal value and red triangles represent the real value in 2012 €, deflated with Statistics Portugal CPI. Green diamonds plot the Kaitz index, defined as the ratio of the minimum to the median wage. Vertical dashed lines represent updates in the nominal minimum wage in the sample period 2012-2016.

Figure 1 illustrates the evolution of the minimum wage from 2011 to 2019, highlighting its constant (real) value 485€ (2012–2013) and 505€ (2014–2015), before increasing to 530€ in 2016. The figure also underscores the broader impact of these changes on the wage distribution, as reflected in the concurrent evolution of the Kaitz index, defined as the ratio of the minimum to median wage.

3.3 Data

This paper leverages *Quadros de Pessoal* (QP), a longitudinal matched employer-employee dataset collected annually by the Ministry for Employment (*Ministério do Trabalho, Solidariedade e Segurança Social*). The survey is mandatory for all private-sector establishments with at least one wage earner and the data reflects the reference month of October eac year. QP provides detailed information on firms, establishments, and workers, uniquely identified and traceable over time.

The dataset includes rich firm- and establishment-level information such as location, ownership structure, legal status, sector, and total employment. Worker-level information includes gender, age, educational attainment, qualifications, hiring date, last promotion, contract type (full- *vs* part-time), occupation, and hours worked, distinguishing between usual and extra hours. It also provides granular wage data, including base pay, regular supplements, and extraordinary payments (e.g., overtime compensation or annual bonuses). Crucially, QP records the collective agreement governing each worker and their professional category, allowing for precise job title definitions.

Beyond its richness, QP offers key additional advantages. Its mandatory nature ensures universal coverage, while employer-reported data mitigates self-reporting bias and attrition, common in wage earner data. Nevertheless, the dataset has limitations. It captures only a reference month per year, preventing within-year reallocation analyses. Workers who are unemployed or out of the labor force during October are unobserved, and the dataset does not distinguish between exits to unemployment, inactivity, or public-sector employment (excluded from QP).

3.3.1 Sample

I compile and clean the raw datasets to ensure consistency of the longitudinal data, following the procedure of Card and Cardoso (2012).[9] The empirical strategy used to identify minimum wage spillovers requires at least two periods with constant minimum wage before each hike. Accordingly, the analysis is focused on the 2012-2016 period to investigate the 2014 and 2016 minimum wage hikes.

The sample includes full-time salaried workers in private firms, aged 18 to 65, working more than 120 hours per month and earning at least 80% of the national minimum wage.[10] Since the minimum wage is defined at a monthly basis, the primary wage measure is the monthly base wage including regular supplements, which better reflects a worker's stable earnings than measures incorporating bonuses or extraordinary payments.[11] Minimum wage and CBA wage floors are nominally set and adjusted periodically rather than through automatic inflation indexation. Thus, the baseline analysis uses nominal wages, though I also present results in real terms (2012 €), deflated using the Consumer Price Index (CPI) from Statistics Portugal (INE).

[9]Data quality checks and selection criteria are detailed in Appendix A of Card and Cardoso (2012).

[10]Apprentices may legally earn 80% of the national minimum wage. For computational feasibility, the results in this draft are based on a 25% random sample, drawn to preserve individual work histories.

[11]Although an implicit hourly minimum wage exists, the law only mandates a monthly threshold without a direct translation to part-time or hourly pay. Moreover, different sectors have different working hours, introducing additional complication to the analysis.

4 Minimum Wage Spillovers

4.1 Identification

The goal of the empirical strategy is to measure the reaction of wages to a minimum wage hike along the wage distribution. I leverage the panel structure of the data to follow workers over time and separate wage growth induced by the policy from both individual and aggregate wage growth trends. The method is well-established in the literature (Brewer et al., 2019; Dube, 2019; Dustmann et al., 2022), and proceeds as follows:

Workers i are assigned to $k = -3, -2, -1, 0, 1, ..., K$ bins based on their baseline wage w_{t-1}. The bin width $h = mw_t - mw_{t-1}$ reflects the minimum wage growth between $t-1$ and t. Each worker is assigned to a bin $b_i = k$ according to the following rules:

- $b_i = -3$ if $w_{i,t-1} < mw_{t-1}$
- $b_i = -2$ if $w_{i,t-1} = mw_{t-1}$
- $b_i = -1$ if $mw_{t-1} < w_{i,t-1} < mw_t$
- $b_i = k$ if $mw_t + h \times k \leq w_{i,t-1} < mw_t + h(k+1), \quad \forall k \geq 0$
- $b_i = K$ if $w_{i,t-1} \geq mw_t + hK$

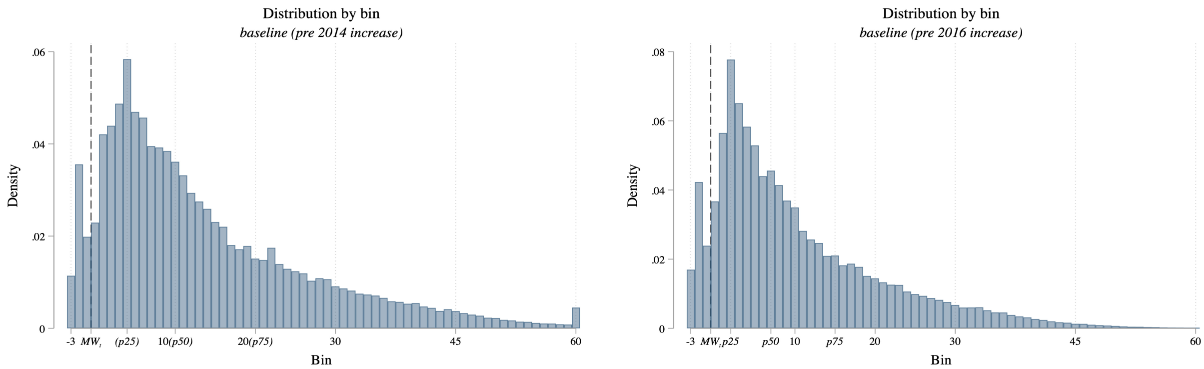
This binning procedure is applied separately for the 2014 (2012–2014 period) and 2016 (2014–2016 period) minimum wage hikes. Figure 2 presents the baseline binned distribution of wages for each cycle. The mass points in bin -2 highlight the high share of workers earning exactly the minimum wage, which ranged between 13% and 20% over the 2012-2016 period, excluding regular supplements.

To estimate bin-specific wage growth, one can regress individual wage changes between $t-1$ and t, $\Delta w_{ikt} = w_{ikt} - w_{ik,t-1}$, on a full set of bin indicators:

$$\Delta w_{ikt} = \sum_{k=-3}^{K} \delta_k \mathbb{1}\{b_i = k\} + \Gamma X_{i,t-1} + \varepsilon_{it}, \tag{6}$$

The coefficients δ_k measure the average wage growth for workers in bin k, conditional on a set of baseline worker, establishment, and firm characteristics $X_{i,t-1}$ that include age (squared), gender, education, nationality, location, and sector.

Figure 2: Binned Distribution at Baseline



Notes: Histogram for the distribution of workers by bins at baseline, per minimum wage hike cycle. The left graph shows plots the 2014 hike, and the right one plots the 2016.

For each minimum wage hike (2014 and 2016), the associated hike cycle consists of two pre-hike years with constant minimum wage and the hike year itself. Wage growth is measured between the former two years (baseline growth) and between the last pre-hike year and the hike year.

The interpretation of δ_k as the causal effect of the minimum wage hike on the wage growth in bin k is threatened by two confounders: heterogeneous macroeconomic conditions, both across time (between periods) and along the wage distribution (between bins); and mean reversion, the notion that lower wages tend to grow at higher rates because of lower base levels and convergence to the mean. Two assumptions are made to address this: A1) stable mean reversion, and A2) stable macro effects. Together, they imply that, absent any policy, bin-specific growth is stable equal across periods. Under those assumptions, differentiating out the baseline bin-specific growth neutralizes the confounding effects. To that end, the baseline specification (6) is modified to:

$$\Delta w_{ikt} = \sum_{k=-3}^{K} \Big(\delta_k \mathbb{1}\left\{b_i = k\right\} + \gamma_k \mathbb{1}\left\{b_i = k\right\} \times MWHike_t \Big) + \Gamma X_{i,t-1} + \eta_c + \varepsilon_{it}, \tag{7}$$

where $MWHike_t$ is an indicator for a minimum wage hike between $t-1$ and t. The δ_k coefficients capture baseline bin-specific growth, netting-out mean reversion and macroeconomic trends. The coefficients of interest, γ_k, measure the causal effect of a minimum wage hike on wage growth in bin k, assuming (A1) and (A2). Specification (7) is estimated separately for each hike and for the pooled sample, in which case I include hike cycle fixed effects η_c.

Positive coefficients for bins below zero capture the direct effect of the minimum wage, reflecting wage adjustments for workers initially earning below the new minimum. These bins are referred to as *MW* bins. Positive coefficients for bins above the new minimum wage reflect spillover effects. The magnitude measures spillover intensity, while the range of affected bins shows how far these effects extend into the wage distribution. These are referred to as *spillover region* bins.

The assumption of stable macroeconomic conditions can be assessed by examining coefficients for higher-wage bins, credibly unaffected by the policy. Estimated coefficients $\widehat{\gamma_k} = 0$ for these bins suggest that broader macroeconomic trends do not bias the wage growth estimates. These coefficients still need to be framed within the macro-context: the period coincided with a severe economic downturn in Portugal, driven by the sovereign debt crisis and subsequent adjustment program, negotiated with the *Troika*. As shown in Figure A.2 in Appendix, this period saw three years of recession (2011–2013), surging public debt exceeding 130% of GDP, and unemployment peaking above 17% in 2013. Modest economic recovery began in 2014, marked by GDP growth and a declining unemployment rate, but shifts in trends occur from 2012.

To further address concerns over changing macroeconomic conditions, I supplement the baseline analysis with difference-in-differences regressions. This approach removes confounding macroeconomic effects by differencing the evolution of the outcome for bins high in the wage distribution, unaffected by minimum wage changes but subject to the same macro conditions.[12] Under a weaker version of assumption (A2), stable *relative* macroeconomic trends across bins (A2.1), these estimates have a causal interpretation. The modified specification accounts for growth in bins above the 75th percentile of the baseline wage distribution:

$$\begin{aligned} \Delta w_{ikt} = & \sum_{k=-3}^{K} \delta_k \mathbb{1}\{b_i = k\} + \sum_{k<p75} \gamma_k \mathbb{1}\{b_i = k\} \times MWHike_t \\ & + \beta_0 MWHike_t + \Gamma X_{i,t-1} + \eta_c + \varepsilon_{it}, \end{aligned} \tag{8}$$

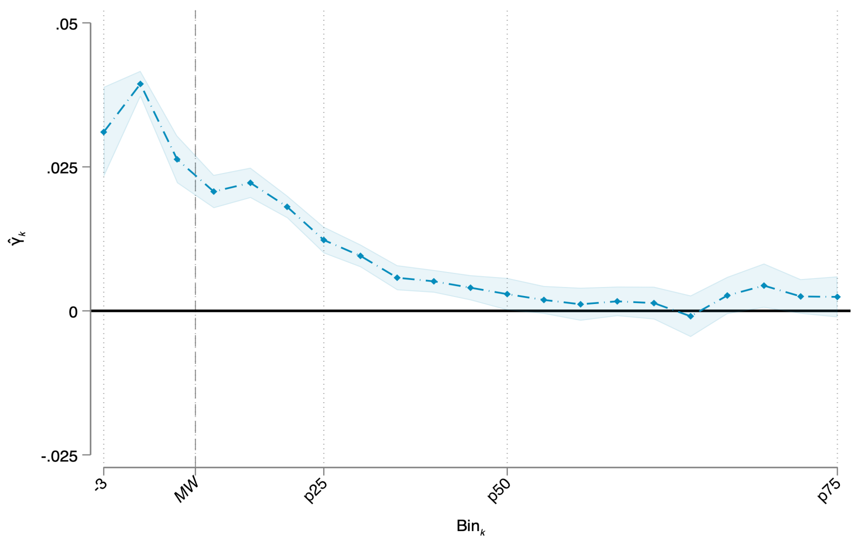
where the second summation includes only bins below the 75th percentile. The coefficients of interest ($\widehat{\gamma_k}$) now measure wage growth caused by the minimum wage hike, net of average control group growth, captured by $\widehat{\beta_0}$. To test result robustness, I consider alternative control group definitions (e.g., above the 60th and 90th percentiles).

[12] This method, known as horizontal difference-in-differences, is widely used in the empirical minimum wage literature (Stewart, 2004; Brewer et al., 2019).

4.2 Results

The main results are displayed in Figure 3. Estimated coefficients $\hat{\gamma}_k$ from regression (7) are plotted, and measure bin-level wage growth net of baseline trends. Under assumptions A1 and A2, these estimates have a causal interpretation. The figure presents results for both hikes combined, while Figures A.3 and A.4 in Appendix A show separate estimates for the 2014 and 2016 hikes. As expected, workers earning below the post-hike minimum wage (bins left of the vertical dashed line) experience wage growth substantially larger than baseline. For workers earning exactly the minimum wage before the hike (bin -2), excess wage growth is about 4.3%, slightly below the average hike magnitude (4.5%), as baseline growth is differenced out.

Figure 3: Wage Growth by bin, net of baseline

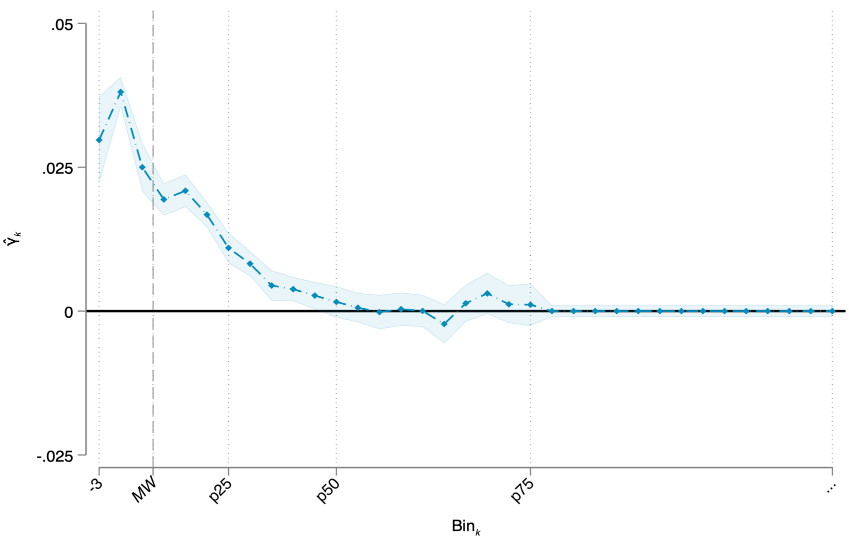


Notes: The bin-level $\hat{\gamma}_k$ coefficients from regression (7) are plotted, measuring the average bin-level nominal wage growth in a minimum wage hike period net of baseline growth. Both hikes included with hike cycle fixed effects. Diamonds represent coefficient estimates, vertical bars the 95% confidence intervals with standard errors clustered at the location level.

The results provide clear evidence of minimum wage spillovers. Wage growth in bins above the new minimum wage remains high, with spillovers detectable up to the 8th bin, corresponding to the 47th percentile of the baseline wage distribution. These findings align with recent evidence on minimum wage spillovers and their role in reducing wage inequality in Portugal (Oliveira, 2023). The first four bins (0 to 3) exhibit strong spillover effects, with average excess wage growth around 2%—the *strong spillover region*. Bins 4 to 7 display weaker, yet positive, spillovers between 0.3% and 1%, which add to bins 0 to 3 in defining the *pervasive spillover region*. To put these magnitudes in perspective, the direct minimum wage effect for affected workers ranges between 2.5% and 4%. The spillover effects in the lowest bins amount to up to 80% of this direct effect, demonstrating the strong impact of the minimum wage on the wage distribution.

Figure 3 highlights another key result: for bins higher in the wage distribution, the estimated effects are consistently null. This supports the assumption of stable macroeconomic conditions and suggests that broader economic trends do not introduce bias into the spillover estimates. To further assess potential biases from time-varying macroeconomic conditions, I estimate equation (8), netting out wage growth in bins above the 75th percentile. Figure 4 plots the adjusted coefficients. The results reinforce the previous findings: once high-wage bin growth is accounted for, spillover effects remain sizable and extend up to the 6th bin. Figures A.5 and A.6 show that the results are robust to different definitions of control group, respectively bins above the 60^{th} and 90^{th} percentiles.

Figure 4: Wage Growth by bin, net of baseline and growth in $> 75^{th}$ pctile bins



Notes: The bin-level $\hat{\gamma}_k$ coefficients from regression (8) are plotted, measuring the average bin-level wage growth in a minimum wage hike period net of both baseline growth and growth in bins higher than the 75^{th} percentile of the baseline wage distribution. Top graph plots the effect on nominal wage, bottom graph on real wage. Diamonds represent coefficient estimates, shaded area the 95% confidence intervals with standard errors clustered at the location level.

Finally, I estimate the average spillover effects from the minimum wage hikes. I divide the workers in three groups based on which region of the baseline wage distribution they occupy. Workers earning less than the post-hike minimum wage, i.e. bins -3 to -1, are labeled MW workers. $Spillover$ bins are those which experience positive spillovers from the minimum wage hikes. To identify them, I rely on the results above and assign workers to the *pervasive spillovers* region is they are between bin 0 and 7 in 2014, and 0 and 8 in 2016, and to the *strong spillovers* between bin 0 and 4 in 2014, and 0 and 3 in

2016.[13] The remaining workers are assigned to a third group, the control. Based on these definitions, I estimate:

$$\Delta w_{ikt} = \sum_{k=-3}^{K} \delta_k \mathbb{1}\{b_i = k\} + \beta MWHike_t + \gamma_0 \times MWHike_t \times MW \\ + \gamma_1 MWHike_t \times Spillover + \Gamma X_{i,t-1} + \eta_c + \varepsilon_{it}, \tag{9}$$

Equation 9 is difference-in-differences (DiD) type specification. The coefficient of interest, γ_1, measures the average spillover effect for workers in *spillover* region bins, net of differential growth in regions higher up in the distribution.

Table 1: Spillover Effects

	Pervasive Spillovers			Strong Spillovers		
	Combined	2014 Hike	2016 Hike	Combined	2014 Hike	2016 Hike
	(1)	(2)	(3)	(4)	(5)	(6)
$MWHike \times Spillover$	0.0089***	0.0089***	0.0096***	0.0128***	0.0134***	0.0143***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$MWHike$	0.0004	-0.0002	0.0006	0.0013**	0.0004	0.0015**
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
Dep. Var mean *pre-hike, spillover*	0.0325	0.0311	0.0337	0.0367	0.0352	0.0380
Bin Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hike Fixed Effects	Yes	-	-	Yes	-	-
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Obs	1 683 996	824 490	859 506	1 683 996	824 490	859 506

Notes: Outcome is the log hourly nominal wage growth. Pervasive spillovers region defined as wages between bin 0 and 7 in 2014 hike, and between bin 0 and 8 in the 2016 hike. Strong spillovers region defined as wages between bin 0 and 4 in 2014 hike, and between bin 0 and 3 in the 2016 hike. $MWHike = 1$ if the minimum wage was hiked between $t-1$ and t. Standard errors clustered at the district level in parentheses.
Significance levels: 0.1 $*$ 0.05 $**$ 0.01 $***$

The results are summarized in Table 1. Columns (1) to (3) report the results for pervasive spillovers, relatively weaker but far-reaching, while columns (4) to (6) reflect the more concentrated strong spillovers. The coefficients compare average excess wage growth following a minimum wage hike for bins in the *spillover region* when compared to bins higher up in the wage distribution. Consistent with the previous results, there is strong evidence of significant spillover effects from the minimum wage. The results show an excess wage growth 0.9% higher in the pervasive spillover region relative to bins higher up in the distribution, and 1.28% higher in the strong spillover region. The effects

[13]Figures A.3 and A.4 in Appendix A show the hike specific regression (8) coefficients.

are large in magnitude: the excess growth in the strong spillover region represents 38% ($0.0128/0.0328$) of the direct effect on minimum wage workers, and a 35% ($0.0128/0.0367$) increase over baseline wage growth for the same workers. In Table A.1 in Appendix, I show that these results are robust to using real wage growth as outcome.

In the rest of the paper, I frequently focus on workers in the spillover region, for whom the analysis is most relevant. The fact that growth in bins higher up in the distribution is constant around 0 is reassuring that, by doing so, I do not bias the estimates of spillovers in any meaningful way. In Table A.2 in Appendix, I compare the magnitude of spillovers from the main DiD specification 9 with simple pre-post analysis over the spillover region. Reassuringly, the estimates are remarkably similar across all specifications.

5 Measuring Firm Organization and Pay Policy

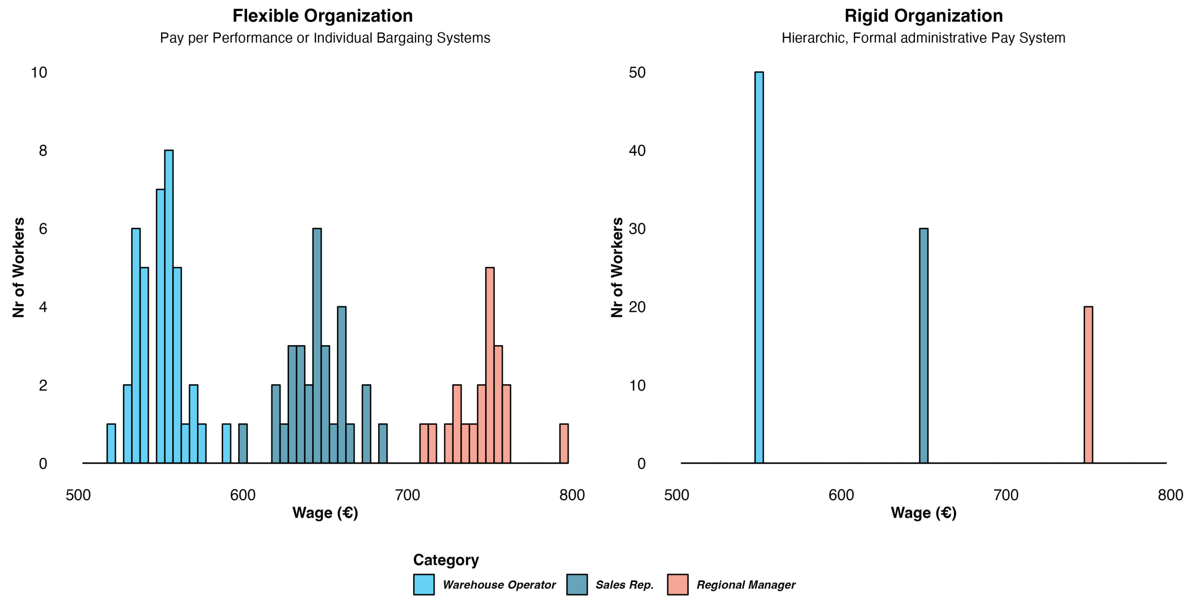
Measuring the internal organization of firms accurately is a crucial step in understanding how it shapes minimum wage spillovers. Resorting to an illustrative example of two different organizational structures based on insights from the model in Section 2, I discuss the proposed rigidity measures.

Consider a firm where $N = 100$ workers have one of three job titles: first tier are warehouse operators, second are sales representatives, and the third are regional managers. Figure 5 illustrates the two alternative ways in which this (fictional) firm can organize and pay its workforce, following the model.

The left-hand side panel of Figure 5 displays a flexible firm. Under this organizational structure, workers in higher job titles earn higher wages, in the stochastic dominance sense, but each individual wage is individually determined. This may arise from pay-per-performance systems (as seen in the model), individual bargaining ability, previous experience, or attractive outside outside offers. In this example, each worker has a different unique wage. Not only may workers move up tiers within the firm, they often receive wage increases within each tier. This results in within-category wage dispersion.

In contrast, the right hand-side panel shows a firm with rigid pay structure. In this opposite extreme, wage is uniquely a function of the job title, and the only way for workers to increase the wage relative to their peers is to move up the firms ladder. This structure corresponds to the tournament pay policy in the model. Here, there is no within-category wage dispersion.

Figure 5: Alternative Within-Firm Organizations



Notes: Alternative within-firm structures for the same fictional 100 employee firm. The left panel represents a flexible structure. Higher categories have higher wages on average, but each worker receives an individual wage. On the right-side panel the firm organizes itself through a tournament-like rigid structure, and the wage is tied to the job title.

I define two main measures of organization rigidity, using the scenarios in Figure 5 as guiding examples. First, following (Machin & Datta, 2024), I consider the number of unique pay points per worker. Formally, letting $\mathcal{W}_{f,t}$ be the set of wages for the N workers employed in firm f at period t, and $|\mathcal{X}|$ denote the cardinality of set $\mathcal{X}$, the number of unique pay points per worker at the firm is given by:

$$PayPoints_{f,t} = \frac{|\mathcal{W}_{f,t}|}{N_{f,t}}$$

In the example flexible firm $PayPoints = 1$ as each worker's wage is unique. In tournament firms, however, all workers in the same tier earn exactly the same wage and $PayPoints = 0.03$ simply reflects the number of tiers per employee. In firms with flexible pay structures, the measure assumes relatively higher values than in firms with rigid structures and well-defined hierarchies.

The second measure targets within-tier wage dispersion (Giupponi & Machin, 2022). In flexible organizations, pay-per-performance and individual bargaining processes generate within-tier wage dispersion. Rigid tournament-like structure imply tier-specific wages with low within-category dispersion. The second measure of rigidity captures this difference and is the firm-level average of the tier-specific dispersion of wages. Leveraging the richness of the data, the baseline measure of tier is the job title, incorporating both the occupational and hierarchical dimensions of a job. Alternative versions of the dispersion measure use the professional categories and qualifications as the appropriate tier measure. Formally, the dispersion measure is defined as:

$$Disp^{jt}_{f,t} = \frac{1}{J}\sum_{j=1}^{J}\sqrt{\frac{1}{N_j}\sum_{i=1}^{N_h}(w_i - \bar{w_j})^2}$$

where w_i is the wage of worker i in job title j, $\bar{w}_h$ and N_j represent the job title's average wage and number of workers, and J is the number of unique job titles at the firm. In the example of Figure 5, the dispersion measure takes value $Disp = 15.36$ for the flexible firm, and value $Disp = 0$ for the rigid firm, as the wage is job title-specific. Similarly to first measure, the dispersion measure also assumes relatively lower values for rigid firms.

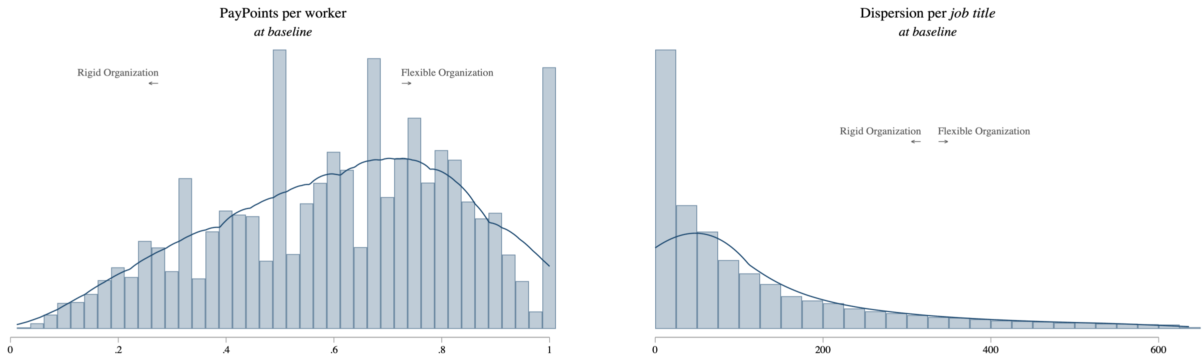
Discretized versions of the rigidity measures classify a firm as rigid if it ranks in the bottom quintile of $PayPoints$ or $Disp$ in turn or, in other words, if the firm places in the top quintile of rigidity according to each measure.

5.1 Descriptives

The pre-hike distributions of rigidity are shown in Figure 6. The number of paypoints per worker is bound between 0 and 1 and therefore signifincatly more concentrated than the dispersion measure. The distribution shows mass points at 0.5 and 1, where the latter is associated with a fully flexible firm (unique wage for each worker). This confirms the fact that the individually bargained wage cushion plays a significant role is the wage setting in Portugal (Card & Cardoso, 2022).

The dispersion measure assumes a left-skewed shape instead. The average dispersion is relatively small, but there is large variation. The distribution displays a long right tail, truncated at the $95th$ percentile in the Figure for presentational purposes. The mass point at 0 represents fully rigid firms, for which there is a unique wage for all workers in a given job title. The mass point at 1 in $PayPoints$ is not necessarily at odds with the mass point at 0 in $Disp$. In smaller firms where job titles have few workers, the number of unique pay points per worker may be large while maintaining low within job title dispersion. To address this point, the main analysis compares varying levels of dispersion and pay points per worker controlling for firm size. Additionally, I provide

Figure 6: Organizational Rigidity Measures



Notes: Figure displays the distribution of the rigidity measures, pre-hike, averaged across hikes. The unit of observation is the firm. The left-hand side panel plots the distribution of $PayPoints$, defined as the number of unique pay points per worker at the firm. The right-hand side plots the distribution of $Disp^{jt}$, defined as the firm-level average of within job title wage dispersion (standard deviation). Rigid organizations take lower values for both measures.

robustness exercises excluding very small firms, where the interpretation of the rigidity measures is less obvious. Conditional on size, fewer pay points per worker indicate higher rigidity, as does lower average dispersion.

A relevant concern is whether differences in rigidity actually reflect different organizational structures, or instead alternative firm characteristics that correlate with such structures. The main candidate, in addition to the firm size discussed above, is sector. The organizational structure of firms is part of their production technology. To the extent that such technology might be sector-specific, the variation in organizational structure of Figure 6 could be driven by the sectoral distribution of firms.

I investigate the relationship between the organizational rigidity measures, firm size, and the sector distribution in Table 2. The distribution of the rigidity measures varies more within than across sectors. Average $PayPoints$ is within the $[0.50, 0.70]$ range, with firms in Retail and Professional, Technical, and Scientific(ProTechSci) sectors showing relatively higher flexibility than other sectors. The inter-quartile range is stable at 0.3 across sectors. $PayPoints$ does not reflect within-sector size differences either, with low correlations peaking at 0.09 in Food and Accommodation. $Disp$ is also stably distributed across sectors. Consistent with the $PayPoints$ measure, firms in the ProTechSci sector stand out as the most flexible according to $Disp$, with a distribution that is right-shifted relative to other sectors. The $Disp$ measure displays somewhat stronger correlation with firm size, reaching 0.21 and 0.25 in the Construction and ProTechSci sector, respectively. This correlation is neither large nor negligible.

Table 2: Organizational Structure Descriptives

	Continuous								Binary		
										AvgSize	
	Avg	*SD*	*min*	*p25*	*p50*	*p75*	*max*	*Corr(Size)*	*%Rigid*	*Rigid*	*Flexible*
PayPoints											
Retail	0.675	0.214	0.037	0.517	0.700	0.833	1	0.07	12.4%	3.34	3.77
Manufacturing	0.583	0.230	0.012	0.400	0.600	0.765	1	0.04	23.9%	5.60	6.05
Construction	0.570	0.227	0.021	0.400	0.571	0.750	1	0.03	25.5%	3.75	3.83
Food and Accomm	0.502	0.219	0.030	0.333	0.500	0.667	1	0.09	35.2%	3.09	3.72
Prof, Tech, and Sci	0.707	0.200	0.0770	0.581	0.721	0.857	1	-0.01	7.8%	3.93	3.92
Transport	0.571	0.260	0.020	0.353	0.571	0.800	1	0.01	30.2%	6.06	5.90
$Disp^{jt}$											
Retail	173	292	0	19	74	196	4539	0.13	18%	2.88	4.38
Manufacturing	123	226	0	13	50	133	4735	0.16	19.6%	4.01	7.03
Construction	112	217	0	0	46	119	3306	0.21	27.8%	3	4.5
Food and Accomm	66	136	0	0	26	82	3032	0.16	36.9%	2.89	4.82
Prof, Tech, and Sci	340	406	0	68	208	458	3914	0.25	9.7%	2.71	4.46
Transport	174	275	0	27	88	195	2430	0.18	14.5%	2.99	6.78

The discretized version of the measures paints a clearer picture. The distribution of rigid firms per sector confirms that these firms are more prevalent in Food and Accommodation and less in ProfTechSci. Rigid firms tend to be somewhat smaller, and the difference is particularly visible when rigidity is defined according the $Disp$ measure. Table 2 highlights that, while organizational rigidity is not determined by correlated observables, it is important to control for size and sector specific responses to the minimum wage to properly isolate the role of rigidity in driving spillovers.

6 Firm Organization and Minimum Wage Spillovers

In this section, I link the causal estimates of minimum wage spillovers of Section 4 with the rigidity measures of Section 5. Testing the predictions of the model in Section 2, I empirically address the relationship between rigiditity and the measure of labor cost shock propagation – spillovers.

6.1 Estimation

The model first posits that spillovers are stronger in firms with minimum wage workers. In rigid, tournament-like firms, spillovers arise from the motivation to preserve the between-tier wage spread and keep workers incentivized. If the minimum wage does not bind, there is no change to the spread or incentives, and there is no need for firms to re-adjust. Similarly, in flexible performance pay firms, wage scheme adjustments are only required when the MW exceeds the base pay component.

I assess the firm-level bite of the minimum wage in two ways. I first compute the share of minimum wage workers at the firm in year t, $MWShare_{f,t}$. Then, to study the intensive margin, I define a dummy $MWSome_{f,t}$ equal to 1 if there are any minimum wage workers at firm f in year t. Focusing on the spillover region (see Section 4), I estimate:

$$\begin{aligned}\Delta w_{i,f,s,t} = \alpha_0 &+ \alpha_1 MWHike_t + \alpha_2 MWBite_{f,t-1} + \beta MWHike_t \times MWBite_{f,t-1} \\ &+ \Gamma X_{i,t-1} + \delta_0 size_{f,t-1} + \delta_1 MWHike_t \times size_{f,t-1} \\ &+ \sum_{s=1}^{S} \delta_s \times MWHike_t + \eta_c + \epsilon_{it},\end{aligned} \tag{10}$$

where $MWBite \in \{MWSome, MWShare\}$ are the measures of firm-level bite of the minimum wage measured at baseline, and $\Delta w_{i,f,t}$, $MWHike_t$, and η_c are defined as before. The coefficient of interest β measures how the strength of spillovers varies with the firm-level bite of the minimum wage. In addition to the baseline controls in X, I include firm size as well as interactions of the minimum wage hike indicator with both firm size and sector dummies δ_s. This ensures that the effect on β does not reflect a spillover effect driven by size or sector dynamics, potentially correlated with the firm-level bite of the minimum wage. Standard errors are clustered at the firm-level, the dimension at which exposure varies.

I then turn to the second hypothesis that spillovers are stronger in firms with more rigid, tournament-like structures. I estimate versions of equation (10) where the minimum wage hike indicator is interacted with the different measures of internal organization at the firm, measured at baseline. I control for firm size, sector, and their interactions with the minimum wage hike indicator to ensure that effects on rigidity-driven spillovers are not driven by correlated sector- or size-specific spillovers. I estimate:

$$\begin{aligned}\Delta w_{i,f,s,t} = \alpha_0 &+ \alpha_1 MWHike_t + \alpha_2 OrgRig_{f,t-1} + \beta MWHike_t \times OrgRig_{f,t-1} \\ &+ \Gamma X_{i,t-1} + \delta_0 size_{f,t-1} + \delta_1 MWHike_t \times size_{f,t-1} \\ &+ \sum_{s=1}^{S} \delta_s \times MWHike_t + \eta_c + \epsilon_{it}\end{aligned} \tag{11}$$

where the $OrgRig \in \{-PayPoints, -Disp\}$ measures enter the specification negatively, such that higher values reflect more rigid structures.

6.2 Core Results

The findings in Table 3 robustly support the hypothesis that spillover effects are significantly stronger in firms for which the minimum wage bites. Columns (1) and (2) investigate the effects in the pervasive spillover region, whereas columns (3) and (4) focus on the strong spillover region, according to the definitions in Section 4. The estimates reported for each interaction refer to coefficient β for the different versions of specification (10): columns (1) and (3) consider the share of minimum wage employment, while columns (2) and (4) show the extensive margin estimates.

Table 3: Spillover Effects by MW Share

	PERVASIVE SPILLOVERS		STRONG SPILLOVERS REGION	
	(1)	(2)	(3)	(4)
$MWHike$	0.0088***	0.0042***	0.0166***	0.0124***
	(0.001)	(0.001)	(0.001)	(0.001)
$MWShare$	-0.0860***	-	-0.0734***	-
	(0.005)		(0.005)	
$MWHike \times MWShare$	0.0944***	-	0.0728***	-
	(0.007)		(0.008)	
$MWSome$	-	-0.0110***	-	-0.0104***
		(0.001)		(0.001)
$MWHike \times MWSome$	-	0.0131***	-	0.0116***
		(0.001)		(0.002)
Bin Fixed Effects	✓	✓	✓	✓
Hike Fixed Effects	✓	✓	✓	✓
Baseline Controls	✓	✓	✓	✓
$Sector \times MWHike$ controls	✓	✓	✓	✓
$Size_{f,t-1} \times MWHike$ controls	✓	✓	✓	✓
Obs	334 831	339 421	149 101	151 421

Note: Pervasive spillovers region defined as bins between 0 and 6 in 2014, and 0 and 8 in 2016. Strong spillovers region defined as bins between 0 and 3 in 2014 hike and 2016 hike. $MWHike = 1$ if the minimum wage was hiked between $t-1$ and t. $MWShare_f$ is the share of minimum wage workers in firm f. $MWSome_f = 1$ if firm f has minimum wage workers. Standard errors clustered at the firm level in parentheses.
Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Firms with minimum wage employment generate, on average, additional 1.31% (1.12%) wage growth for workers in the pervasive (strong) spillover region compared to firms without minimum wage employment. The effects are large and precisely estimated. Spillovers are four times as large for firms with minimum wage employment than for firms with no minimum wage workers, considering the pervasive spillovers region. Considering the strong spillovers region, firms for which the minimum wage bites generate 93% larger spillovers. The result that spillovers are larger in firms with minimum wage employment is consistent with the model and with previous findings in the literature (e.g. Forsythe (2023)).

The large difference in the relative size of spillovers in the pervasive and strong spillover regions is driven mostly by the difference in baseline spillovers for firms without minimum wage employment. While the additional wage growth in firms with minimum wage employment is around 1% in both regions, the baseline spillover for firms without minimum wage employment is 1.24% in the strong spillover region but only 0.42% in the pervasive region.

The extensive margin also plays a role. Firms with higher shares of minimum wage employment generate stronger spillovers. Focusing on the pervasive spillover region, a standard deviation increase in the share of minimum wage employment at the firm (8.6%) is associated with additional 0.81% spillover, representing a 90% increase over the baseline spillover. In the strong spillovers region, a standard deviation increase in the share of minimum wage employment (10.6%) is associated with additional 0.77% wage growth for spillover workers, a 46% increase. Firms with higher shares of minimum wage employment experience lower baseline wage growth in the spillover region. The additional spillover effect generated by firms with minimum wage employment fully offsets the baseline difference with respect to firms without minimum wage workers.

In Figure 7, I investigate non-linearities in the strength of spillovers by share of minimum wage employment. The figure plots the coefficients and 95% confidence intervals of the coefficients γ_h from a series of separate regressions of the form:

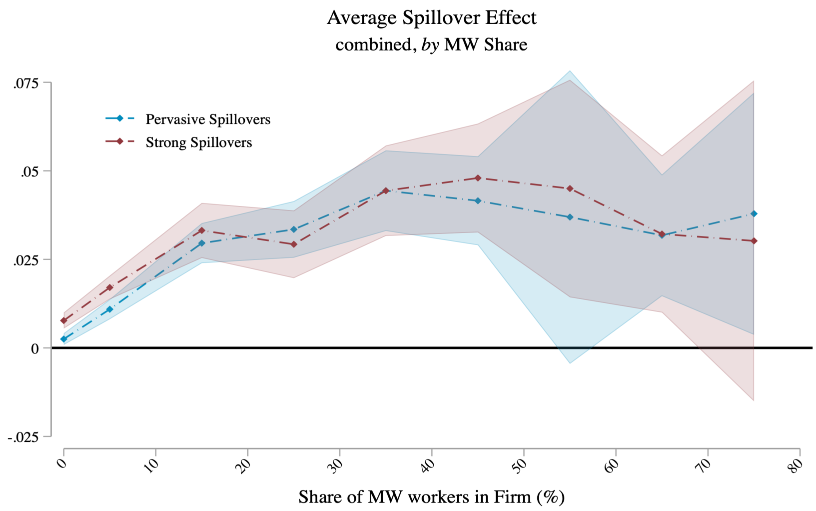
$$\begin{aligned} \Delta w_{ikt} = & \alpha_0 + \gamma_h MWHike_t + \Gamma X_{i,t-1} + \eta_c + \varepsilon_{it}, \\ & \forall h = \{0, 5, 15, 25, ..., 65, 75\} \end{aligned} \tag{12}$$

where α_0 measures the conditional average baseline wage growth for spillover workers, and $h = \{0, 5, 15, 25, ..., 75\}$ specify that the regression was run for firms with minimum wage employment shares between $h_{-1}\%$ and $h\%$. For example, if $h = 15$, the regression is estimated for firms with minimum wage employment between 5% and 15%. The coefficients of interest $\hat{\gamma}_h$ measure the spillover effect for firms with minimum wage exposure in the h-specified range.

Spillovers are modest for firms without minimum wage employment. The strength of spillovers grows sharply with the share of minimum wage employment until around 20%. The rate of growth decreases between 20% and around 35%, from which point the strength of spillovers plateaus, or slowly decreases. Estimates become imprecise for higher shares of the minimum wage employment, as the sample size falls.

These findings can be related to the relative importance of the tournament mechanism in driving spillovers. As the firm's reliance on minimum wage employment first increases, so does the importance of preserving the effort incentives for those workers, a relatively more important component in the firms' production process. However, this mechanism only works up to a point. As the size of minimum wage employment relative to that of higher tiers becomes large enough, the probability of promotion for minimum wage workers is low enough that smaller increases in the promotion wage are sufficient to preserve the workers' incentives.

Figure 7: Spillover Effect by Share of Firm Minimum Wage Workers



Notes: Average spillover effect across hikes by firm-level share of minimum wage workers employment. Each point represents the coefficient of a regression of individual wage growth on a minimum wage hike indicator, measuring the spillover effect. Regressions are estimated separately run for each of the plotted baseline shares (0%, and 5% to 75% on 10% intervals). The blue series plots results for the pervasive spillover region, while the red series shows the strong spillovers region results (see Section 4).

In Table 4, I show that spillovers are stronger in firms with rigid structures, where the tournament mechanism operates more meaningfully. This is confirmed by positive and significant estimates on the $OrgRig \times MWHike$ interaction across specifications. Panel A and B report the results for the pervasive and strong spillovers region, respectively. Columns (2) and (6) show that rigid firms according to the $PayPoints$ measure generate additional 0.85% and 0.69% wage growth with respect to non-rigid firms in the pervasive strong spillovers region, respectively. These are large effects, representing 44% to 100%

increase in the magnitude of the spillover effect. Considering the $Disp$ measure, the spillover effect is 34% and 72% larger for rigid firms in the strong and pervasive spillovers region, respectively (Columns (8) and (4)).

The additional spillover effect that arises from working at rigid firms is similar across regions, and fully offsets the baseline difference in spillovers for $PayPoints$ and in half for $Disp$. The baseline spillover is considerably larger in the strong spillover region, where the relative importance of other wage bargaining mechanisms is more important. This is the region closest to the minimum wage, where performance pay related emerge (see Section 2), and individuals are more likely to renegotiate due to fairness concerns (Giupponi & Machin, 2022), relative positions in direct supervision hierarchies, or last place aversion (Kuziemko et al., 2014; Forsythe, 2023).

The continuous measures confirm these results. To provide a meaningful interpretation to the estimates magnitude, I show both the additional wage growth for spillover workers and the percent increase in the spillover effect associated with moving from the $25th$ to the $75th$ percentile of the rigidity distribution. Rigidity as measured by $PayPoints$ suggests a larger importance of the tournament mechanism in generating spillovers. Column (5) shows that moving from the $25th$ to the $75th$ percentile of rigidity in $PayPoints$ in the strong spillover region generates additional 0.5% wage growth, a 30% increase in the magnitude of the spillover. Column (1) shows that in the pervasive spillover region, the same 0.5% wage growth represents a 50% increase in spillover magnitude.

The effects are smaller when rigidity is measured through $Disp$. In part, this can be attributed to the much higher concentration in $Disp$ (see Section 5), implying lower change in a move from the $25th$ to $75th$ percentiles. As shown in Column (3) and (7), moving from percentile 25 to 75 is associated with 0.08% additional wage growth in pervasive spillover region and 0.16% in strong spillovers region. These represent between 7% and 9% increase in the magnitude of the spillover.

Together, the results in this section provide clear evidence that the organizational structure of firms matters for the spread of a labor cost shock, represented here by the strength of minimum wage spillovers. Firms with more rigid structures and well defined hierarchies respond to minimum wage hikes by generating stronger spillovers, providing evidence of the tournament mechanism at work.

Table 4: Spillover Wage Effects

	A. Pervasive Spillovers Region				B. Strong Spillovers Region			
	$PayPoints$		$Disp^{jt}$		$PayPoints$		$Disp^{jt}$	
	Continuous	*Discrete*	*Continuous*	*Discrete*	*Continuous*	*Discrete*	*Continuous*	*Discrete*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$MWHike$	0.0218***	0.0085***	0.0122***	0.0088***	0.0260***	0.0157***	0.0206***	0.0160***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
$OrgRig$	-0.0192***	-0.0069***	-0.0062***	-0.0137***	-0.0214***	-0.0084***	-0.0088***	-0.0139***
	(0.003)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)
$OrgRig \times MWHike$	0.0197***	0.0085***	0.0011*	0.0063***	0.0155***	0.0069***	0.0030***	0.0055***
	(0.004)	(0.002)	(0.001)	(0.001)	(0.004)	(0.002)	(0.001)	(0.002)
P25 → P75 Rigidity Effect								
Additional Wage Growth	0.0050	-	0.0008	-	0.0050	-	0.0016	-
Increase in Spillover Effect	49.9%	-	7.2%	-	30.6%	-	8.8%	-
Magnitude								
Baseline Difference Offset	-	123%	-	46%	-	82%	-	40%
Relative Spillover Increase	-	100%	-	72%	-	44%	-	34%
Bin Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
Hike Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
Baseline Controls	✓	✓	✓	✓	✓	✓	✓	✓
$Sector \times MWHike$ controls	✓	✓	✓	✓	✓	✓	✓	✓
$Size_{f,t-1} \times MWHike$ controls	✓	✓	✓	✓	✓	✓	✓	✓
Obs	339 421		288 018		151 421		129 749	

Notes: Pervasive spillovers region defined as bins between 0 and 6 in 2014, and 0 and 8 in 2016. Strong spillovers region defined as bins between 0 and 3 in 2014 hike and 2016 hike. $MWHike = 1$ if the minimum wage was hiked between $t-1$ and t. $PayPoints$ is the number of unique wages per worker at the firm. $Disp^{jt}$ is the firm-level average of within job title wage dispersion. Both enter regressions negatively, and are thus measures of organizational rigidity $OrgRig$. Measures of rigidity are computed at the firm-level. Standard errors clustered at the firm-level in parentheses.
Significance levels: 0.1 $*$ 0.05 $**$ 0.01 $***$

6.3 Robustness and Alternative Explanations

To alleviate concerns that the effects on the organizational rigidity measures may in fact be measuring correlated dimensions of firms, I perform a battery of robustness checks. First, given that firms with higher exposure to the minimum wage generate stronger spillovers, if the internal organization of firms is correlated with minimum wage exposure, it could be that the rigidity measure is just capturing differential baseline exposures to the policy. I augment the binary version of specification (11) to control for baseline differences in minimum wage exposure and exposure-specific reactions to the policy:

$$
\begin{aligned}
\Delta w_{i,f,s,t} = \alpha_0 &+ \alpha_1 MWHike_t + \alpha_2 OrgRig_{f,t-1} + \beta MWHike_t \times OrgRig_{f,t-1} \\
&+ \Gamma X_{i,t-1} + \delta_0 size_{f,t-1} + \delta_1 MWHike_t \times size_{f,t-1} \\
&+ \sum_{s=1}^{S} \delta_s \times MWHike_t + \gamma_1 MWBite_{f,t-1} \\
&+ \gamma_2 MWShare_t \times MWShare_{f,t-1} \eta_c + \epsilon_{it}
\end{aligned} \tag{13}
$$

The coefficient β measures the additional spillovers for rigid firms, taking as comparison flexible firms with the same baseline exposure to the minimum wage and controlling for exposure related reactions to the minimum wage.

The results are displayed in Column (1) and (5) of Table 5, under the label MW $Exposure$. The results do not change in any significant way. The coefficient on the stronger spillover effect for rigid firms is slightly reduced in magnitude across both outcomes and both spillover regions, but the reduction is small and the positive effect remain significant. This finding confirms that the organizational rigidity measures and their effect on spillovers do not reflect the effect of differential firm-level exposures to the minimum wage.

The interpretation of the rigidity measures is less obvious in very small firms. There, differences in the rigidity measures could simply reflect differences in the number of different layers and the number of workers per layer. I address this concern in two different ways. First, I exclude very small firms from the analysis and report results for specification 11 for firms with more than 5 employees.[14] Second, I report the results for the same specification controling for the number of job titles at the firm. This ensures that

[14] The average firm size in the QP data, and in Portugal, is very small. In the data, excluding single-worker firms, the average number of workers in a firm 3, and 5 is the 75^{th} percentile.

variation in the rigidity measure does not reflect composition effects in very small firms or differences in the number of job titles.

The results, shown in columns (2)-(3) and (6)-(7), provide two interesting insights. First, focusing on columns (3) and (7) *vs* (2) and (6), it becomes clear that controlling for the number of different job titles at the firm makes virtually no difference. Second, excluding very small firms either leaves the main results unchanged ($PayPoints$) or even increases the magnitude of the effect, when compared to the baseline estimates in Table 4. These findings are reassuring that the measures of internal rigidity and their effects were not confounded by different composition of firms in terms of number of job titles, nor driven by very small firms, where their interpretation is requires caution.

Differences in the job title dispersion of wages between firms might not related to organizational differences but instead to the workforce composition. If differences in dispersion are merely reflecting differences in the skills of workers between firms, interpretation of the organization effects becomes more subtle. I address this issue by including controls for the firm-level skill dispersion in a modified version of specification (11). Following Iranzo et al. (2008), my measure of within-firm skill dispersion is the firm-level variance of worker effects from an AKM wage equation (Abowd et al., 1999). The results are displayed in columns (4) and (7). The magnitude of the effects is slightly reduced for both rigidity measures and both spillover regions, but their qualitative interpretation does not change in any significant way. Rigid firms generate stronger spillovers, even after accounting for the baseline differences in within-firm skill dispersion. This highlights that the rigidity measures are capturing elements of the firm organization and pay policy rather than differences in skill distribution between firms.

In a closely related paper, Forsythe (2023) studies manufacturing firms in the U.S. and finds that supervisory relations drive spillovers, as spillover-consistent patterns emerge only for supervisors.

To test this hypothesis, I rely on the QP data to identify supervisors. Following Caliendo et al. (2020), I define as supervisor $Sup_{t-1} = 1$ a worker in the "supervisors and team leaders" qualifications category. I estimate versions of equation (9) for supervisors and non-supervisors separately. In a complementary specification, I include a supervisor dummy and interact it with the $Spill \times Post$ term, to test if spillovers materialize to different extents for supervisors and non-supervisors.

The results are shown in Table 6. First, interaction terms are small and statistically

Table 5: Robustness

	$PayPoints$				$Disp^{jt}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Pervasive Spillovers Region								
$OrgRig \times MWHike$	0.0071***	0.0086***	0.0086***	0.0076 ***	0.0058***	0.0078***	0.0078***	0.0052***
	(0.002)	(0.003)	(0.003)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)
Obs	339 421	208 518	288 018	339 416	284 280	194 681	194 681	288 014
Panel B. Strong Spillovers Region								
$OrgRig \times MWHike$	0.0059***	0.0059**	0.0059**	0.0056***	0.0052***	0.0086***	0.0087***	0.0040**
	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Obs	151 421	85 634	85 634	151 418	129 749	80 810	80 810	129 746
Robustness Exercise	$MW\ Exposure$	*Exc. Small Firms* -	*+ nr job titles*	*Worker Skills*	$MW\ Exposure$	*Exc. Small Firms*	*+ nr job titles*	*Worker Skills*
Bin Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
Hike Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
Baseline Controls	✓	✓	✓	✓	✓	✓	✓	✓
$Sector \times MWHike$ controls	✓	✓	✓	✓	✓	✓	✓	✓
$Size_{f,t-1} \times MWHike$ controls	✓	✓	✓	✓	✓	✓	✓	✓

Notes:Pervasive spillovers region defined as bins between 0 and 6 in 2014, and 0 and 8 in 2016. Strong spillovers region defined as bins between 0 and 3 in 2014 hike and 2016 hike. $MWHike = 1$ if the minimum wage was hiked between $t-1$ and t. $PayPoints$ is the number of unique wages per worker at the firm. $Disp^{jt}$ is the firm-level average of within job title age dispersion. Both enter regressions negatively, and are thus measures of organizational rigidity $OrgRig$. Measures of rigidity are computed at the firm-level. *MW Exposure* controls for baseline firm-level exposure to the minimum wage, and exposure-specific reactions to the policy. *Exc. Small Firms* excludes firms with less than 5 employees. *+ nr job titles* additionally controls for the number of job titles at the firm. *Worker Skills* controls for within-firm skill dispersion and skill-dispersion specific reactions to the minimum wage. Skill dispersion is defined as the within-firm variance of worker effects from an AKM wage equation (Abowd, Kramarz, & Margolis, 1999; Iranzo, Schivardi, & Tosetti, 2008). Measures of rigidity, exposure, and skill dispersion are computed at the firm-level. Standard errors clustered at the firm-level in parentheses.
Significance levels: 0.1 $*$ 0.05 $**$ 0.01 $***$

Table 6: Spillover Effects and Supervisory Spans of Control

	Pervasive Spillovers			Strong Spillovers		
	Sups	Non-Sups	All	Sups	Non-Sups	All
	(1)	(2)	(3)	(4)	(5)	(6)
$MW Hike \times Spillover$	0.0114***	0.0086***	0.0089***	0.0125*	0.0117***	0.0119***
	(0.004)	(0.001)	(0.001)	(0.007)	(0.001)	(0.001)
$MW Hike \times Spillover \times Sup$			-0.0027			-0.0042
			(0.003)			(0.005)
Bin Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hike Fixed Effects	Yes	-	-	Yes	-	-
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Obs	77 957	1 112 072	1 190 029	77 957	1 112 072	1 190 029

Notes: Outcome is the log hourly nominal wage growth. Pervasive spillovers region defined as wages between bin 0 and 7 in 2014 hike, and between bin 0 and 8 in the 2016 hike. Strong spillovers region defined as wages between bin 0 and 4 in 2014 hike, and between bin 0 and 3 in the 2016 hike. Supervisors are defined as workers in the "supervisors and team leaders" category, following Caliendo et al. (2020). Standard errors clustered at the district level in parentheses.
Significance levels: 0.1 * 0.05 ** 0.01 * * *

insignificant at all conventional levels, indicating spillovers of comparable magnitude between supervisors and non-supervisors. Second, spillover-consistent patterns also emerge for non-supervisors, as shown by positive and significant spillover coefficients in the non-supervisor sample. When considering the samples separately, the coefficients on spillovers are larger in the supervisor sample. Together with a negative and insignificant interaction term, this suggests that, by splitting the samples, we may be selecting along other characteristics (including rigidity) explaining larger spillovers. The results show that, in the Portuguese context, supervisory spans of control do not fully explain the emergence of spillovers, and reinforce the role of a complementary mechanism such as the one studied in this paper.

Reassuringly, the core finding of this paper that rigid firms generate stronger spillover effects is robust to all different specification and alternative explanations.

7 Conclusion

This article studies how the internal organization of firms affects the propagation of shocks. I focus on a particular dimension of the organizational structure, rigidity, and study a labor cost shock of particular policy importance, the minimum wage.

I find robust evidence that firms with rigid structures, characterized by fewer pay points per worker and lower within job title wage dispersion, respond to minimum wage hikes with stronger increases of higher wages, amplifying spillovers. A simple theoretical model that guides my interpretation of these results. I show how introducing a binding minimum wage to firms with differnt organizational structures and associated pay policies, and show that stronger spillovers arise in firms with rigid organization structures, as the tournament mechanism operates.

While the minimum wage is a particularly relevant shock to study, the findings of this paper offer much broader insights. The organization of the firm matters for how shocks propagate regardless of their policy-induced nature. Other shocks that change the relative pay of workers in different positions in the wage distribution can have heterogeneous impacts in rigid *vs* flexible firms. Examples include technology shocks that complement low- (or high-) skilled workers, or immigration shocks. These affect the different tiers of the firm differently, and the extent and form of adjustments will vary according to the rigidity of the organization.

Overall, this paper highlights the importance of understanding the organizational structure of firms, and in particular rigidity, to properly assess the impacts of economic shocks. Different organization structures can have relevant impacts on the shock-induced costs faced by firms, and for wage inequality through differential pay adjustments. The question of why some firms select into rigid structures while others prefer flexible ones is beyond the scope of this paper, and an avenue for future research.

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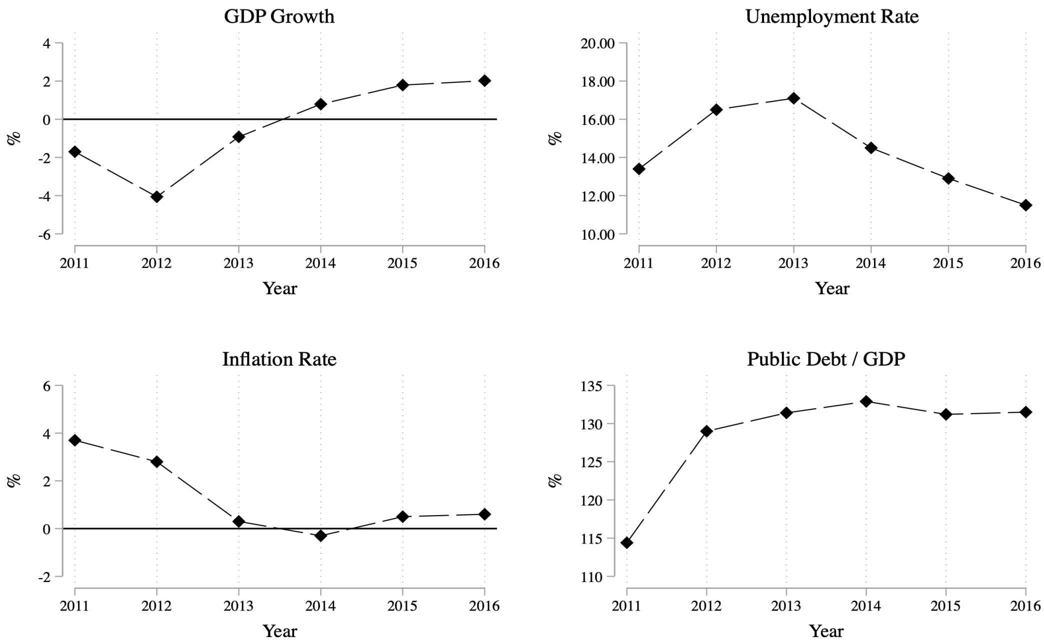
Appendix A Figures and Tables

Figure A.1: Wage Floors per Job Title

Grupo	Profissões e categorias profissionais	Grupos profissionais	Retribuições mínimas
I	Analista informático de sistemas	Esc.	950,00 €
	Contabilista (grau III)	Esc.	
	Técnico oficial de contas (grau III)	Esc.	
	Geómetra	Top.	
	Técnico superior de segurança no trabalho (grau III)	TST	
	Técnico (grau III)	Téc.	
	Diretor de serviços	-	
IV	Técnico de obra (grau II)	CCOP	805,00 €
	Técnico de recuperação (grau II)	CCOP	
	Assistente técnico (grau I)	El.	
	Contabilista (grau I-A)	Esc.	
	Operador de computador III	Esc.	
	Programador mecanográfico	Esc.	
	Técnico de contabilidade	Esc.	
	Técnico oficial de contas (grau I-A)	Esc.	
	Técnico de recuperação (grau II)	Mad.	
	Técnico de recuperação (grau II)	Met.	
	Desenhador-medidor II	T.D.	
	Desenhador preparador de obra II	T.D.	
	Medidor orçamentista I	T.D.	
	Topógrafo (grau I)	Top.	
	Técnico de segurança no trabalho (grau I)	TST	
	Técnico (grau I-A)	Téc.	
	Chefe de secção	-	

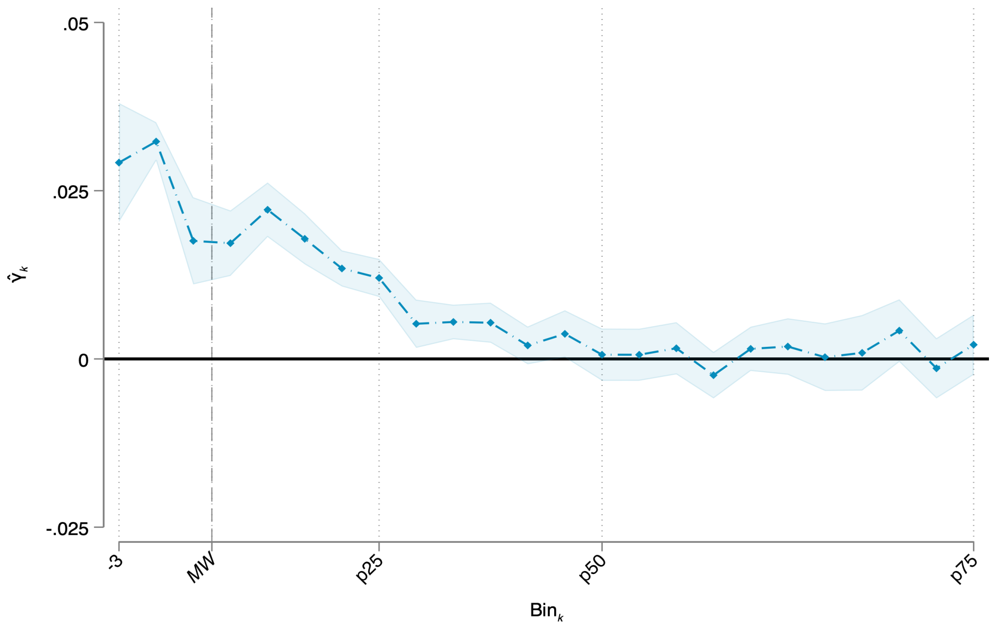
Notes: CBA Wage Floor Tables example. CCT signed between AECOPS, AICCOPN, and AICE (employer associations), and FETESE, FE, and SINDEL (trade unions). BTE 26, 15/07/2017, with updates of July 2019. Click here to see.

Figure A.2: Macroeconomic Conditions 2011-2016



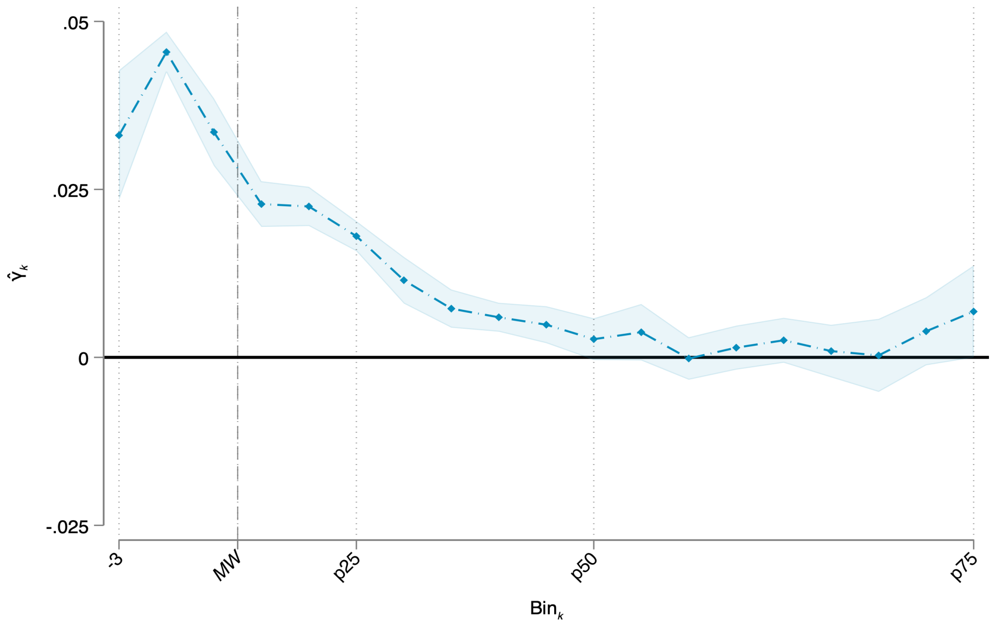
Notes: Yearly measures. Real GDP growth, base prices 2016. Unemployment rate for individuals aged 16-74. Inflation rate is measured by Statistics Portugal Consumer Price Index. Public Debt to GDP defined as gross debt of public administrations as a share of GDP. Sources: Statistics Portugal, PORDATA.

Figure A.3: 2014 MW Hike: Wage Growth by bin, net of baseline



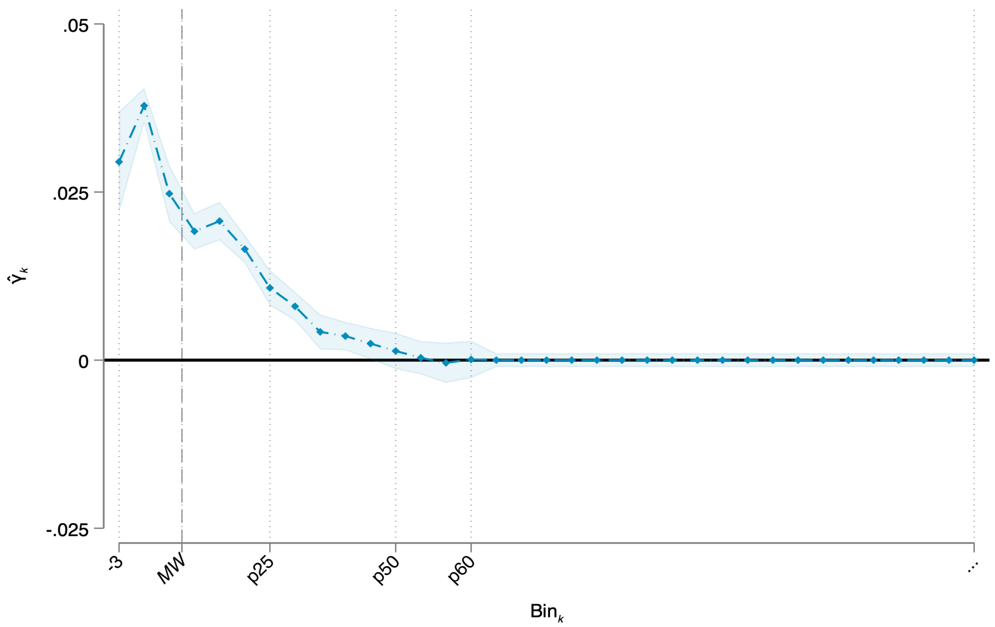
Notes: The bin-level $\hat{\gamma}_k$ coefficients from regression (7) are plotted, measuring the average bin-level nominal wage growth in a minimum wage hike period net of baseline growth. 2014 hike cycle. Diamonds represent coefficient estimates, vertical bars the 95% confidence intervals with standard errors clustered at the location level.

Figure A.4: 2016 MW Hike: Wage Growth by bin, net of baseline



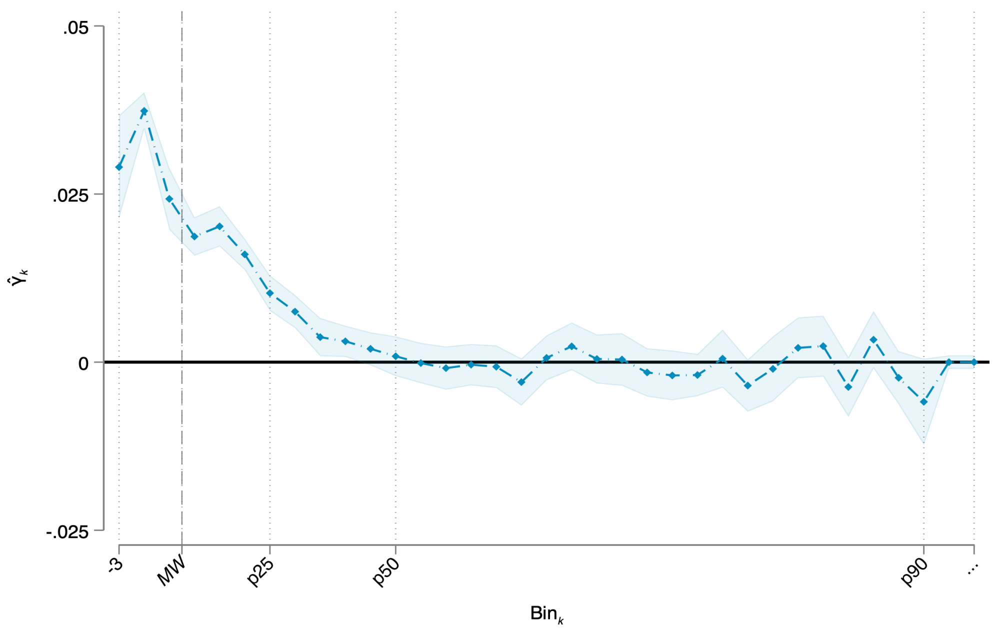
Notes: The bin-level $\hat{\gamma}_k$ coefficients from regression (7) are plotted, measuring the average bin-level nominal wage growth in a minimum wage hike period net of baseline growth. 2016 hike cycle. Diamonds represent coefficient estimates, vertical bars the 95% confidence intervals with standard errors clustered at the location level.

Figure A.5: Wage Growth by bin, net of baseline and growth in $> 60^{th}$ pctile bins



Notes: The bin-level $\hat{\gamma}_k$ coefficients from regression (8) are plotted, measuring the average bin-level wage growth in a minimum wage hike period net of both baseline growth and growth in bins higher than the 60^{th} percentile of the baseline wage distribution. Diamonds represent coefficient estimates, shaded areas the 95% confidence intervals with standard errors clustered at the location level.

Figure A.6: Wage Growth by bin, net of baseline and growth in $> 90^{th}$ pctile bins



Notes: The bin-level $\hat{\gamma}_k$ coefficients from regression (8) are plotted, measuring the average bin-level wage growth in a minimum wage hike period net of both baseline growth and growth in bins higher than the 90^{th} percentile of the baseline wage distribution. Diamonds represent coefficient estimates, shaded areas the 95% confidence intervals with standard errors clustered at the location level.

Table A.1: Spillover Effects

	Pervasive Spillovers			Strong Spillovers		
	Combined	2014 Hike	2016 Hike	Combined	2014 Hike	2016 Hike
	(1)	(2)	(3)	(4)	(5)	(6)
$MW Hike \times Spillover$	0.0110***	0.0114***	0.0130***	0.0150***	0.0145***	0.0187***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$MW Hike$	0.0089***	0.0134***	0.0032***	0.0101***	0.0147***	0.0046***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Dep. Var mean *pre-hike, spillover*	0.0185	0.0185	0.0185	0.0245	0.0253	0.0237
Bin Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hike Fixed Effects	Yes	-	-	Yes	-	-
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Obs	1 683 996	824 490	859 506	1 683 996	824 490	859 506

Notes: Outcome is the log hourly real wage growth. Pervasive spillovers region defined as wages between bin 0 and 7 in 2014 hike, and between bin 0 and 8 in the 2016 hike. Strong spillovers region defined as wages between bin 0 and 4 in 2014 hike, and between bin 0 and 3 in the 2016 hike. $MW Hike = 1$ if the minimum wage was hiked between $t-1$ and t. Standard errors clustered at the district level in parentheses.
Significance levels: 0.1 $*$ 0.05 $**$ 0.01 $***$

Table A.2: Spillover Effects: Pre-Post Analysis in Spillover Region

	Pervasive Spillovers			Strong Spillovers		
	Combined	2014 Hike	2016 Hike	Combined	2014 Hike	2016 Hike
	(1)	(2)	(3)	(4)	(5)	(6)
$Post$	0.0095***	0.0085***	0.0102***	0.0150***	0.0137***	0.0162***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Bin Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hike Fixed Effects	Yes	-	-	Yes	-	-
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Obs	665 231	304 029	361 202	665 231	304 029	361 202

Notes: Outcome is the log hourly real wage growth. Pervasive spillovers region defined as wages between bin 0 and 7 in 2014 hike, and between bin 0 and 8 in the 2016 hike. Strong spillovers region defined as wages between bin 0 and 4 in 2014 hike, and between bin 0 and 3 in the 2016 hike. $MW Hike = 1$ if the minimum wage was hiked between $t-1$ and t. Standard errors clustered at the district level in parentheses.
Significance levels: 0.1 $*$ 0.05 $**$ 0.01 $***$