

Sources of the Union Wage Gap: Results from High-Dimensional Fixed Effects Regression Models

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Abstract

We estimate the impact of union density on wages using Portuguese matched employer-employee-contract data, extending Gelbach's (2016) omitted variable bias decomposition procedure to obtain the contribution of worker, firm, and job-title heterogeneity to the union wage premium. The principal result is the dominance of the firm fixed effect: the allocation of workers among firms with different wage policies. For their part, the unobserved skills of union workers have only a modest impact on wages. In turn, job titles reflect the average contract in the collective agreement, while the wage cushion offers firms a margin of flexibility, partially undoing increases in the bargained wage. Finally, there is little to suggest that the union wage gap is influenced by improved match quality.

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I. Introduction

In continental Europe, the architecture of wage bargaining systems typically leads to coverage rates that exceed – often by a considerable margin – union density rates. The pervasive presence of extension mechanisms that generalize union wage agreements throughout industry is responsible for this asymmetry. The idiosyncrasies of the European wage setting system thus pose new challenges for the estimation of the union wage premium. In this study, we take advantage of an exceptional longitudinal dataset with unique worker, firm, wage contract, and job title identifiers, combined with a novel decomposition procedure, to address a number of questions aimed at providing a better understanding of what lies behind the union wage gap.

Organized in terms of the order in which they are answered, the eight research questions asked in the present treatment are as follows. First, can we trust conventional estimates of the union wage gap that imply a wage gain that is proportional to union density (e.g. Blanchflower and Bryson, 2004, 2007)? Second, which particular components of a worker’s remuneration are most elevated by union bargaining (e.g. Rees, 1960; Freeman, 1981; Buchmueller, Dinardo, and Valletta, 2002)? Third, what would be the outcome were unionized workers randomly assigned to firms? Or, expressed another way, do wages determine the allocation of unionized workers among firms (e.g. Hirsch and Addison, 1986)? Fourth, by analogy with the controversy often surrounding public-sector pay, to what extent is the union wage premium related to higher-paying job titles or more generous promotion policies within unionized firms? Fifth, do unionized workers possess unobserved characteristics that make them more productive (e.g. Hirsch, 2004; Card, 1996)? Sixth, how is union bargaining power manifested? For example, how might the wage distribution look if workers were paid exactly the bargained wage determined at industry level, and what precisely is the role of wage setting at the firm level (e.g. Jung and Schnabel, 2011)? Seventh, and relatedly, can employers undo at firm level, via the wage cushion, the bargained wages agreed to at industry level (e.g. Cardoso and Portugal, 2005)? Finally, is the union-wage premium materially influenced by a better matching of workers with their employers, as might be produced by different hiring and retention policies (e.g. Torres et al., 2015)?

This paper provides estimates of the union wage gap in Portugal, a nation until recently lacking independent data on union density at firm level, and proceeds to decompose that gap in terms of the contribution of worker, firm, and job title heterogeneity. Estimation proceeds in two main stages. In the first stage, possessing data on the share of workers organized in each firm, if not the union status of any individual worker, a union density-specific fixed effects model is estimated for individual earnings, where the fixed effect represents a different intercept in each worker’s wage equation. A kernel regression is computed allowing for a nonlinear functional form of the effect of union density on wages. Completing this

first stage of our inquiry, we provide bootstrap confidence intervals. (In parallel with findings for the non-linear model, a linear version is discussed.)

The second stage of the analysis considers the three-fold contribution of the productivity of workers, their occupational distribution, and the compensation policies and human resource strategies of firms to the union wage gap. Specifically, we are able to quantify the impact of each high-dimension fixed effect on the union density fixed effect and the wage gap curve, using Gelbach (2016) decompositions.¹

The plan of the paper is as follows. To set the scene, section II outlines the machinery of collective bargaining in Portugal. Section III describes the unique datasets used in this inquiry. The modeling strategy is outlined in section IV, prior to the presentation of the detailed empirical results in Section V. Section VI contains the results of a robustness check. A summary concludes.

II. The Bargaining Framework

Portuguese law makes provision for three types of collective bargaining at national, regional, and local level. First, there is firm-level bargaining between an individual company and one or more unions. These so-called *Acordos de Empresa* (or AEs) are important in the oil sector and transport and communications. Second, there are collective agreements signed by several employers that are not part of an employers' association and one or more trade unions, known as *Acordos Colectivos de Trabalho* (or ACTs), that are significant in the financial sector and utilities. However, it is industry-level/branch or sectoral agreements, so-called *Contratos Colectivos de Trabalho* (CCTs), negotiated between one of more employers' associations and one or more unions, that predominate. CCTs in conjunction with extension agreements (described below) that are very largely based on them explain levels of collective bargaining coverage in the order of 90 percent of workers at a time when union density is a little over 10 percent. The vast majority of agreements are signed by unions linked to the two major union confederations: the CGPT-IN or General Confederation of Portuguese Workers, and the UGT or General Workers' Union. The gaps in coverage are largely in personal and other services, and in public administration where, despite centralized negotiations between the government and the trade unions, wages are decided upon unilaterally by the government. The wages of employees in publicly-controlled companies, such as public transportation and the postal service, are collectively bargained in the normal way.

The industry-level or sectoral agreements may cover a range of industry-specific occupations but as the system does not rule out parallelism or overlapping collective agreements a single enterprise may be

¹ Formally, the difference between the union density coefficient in a base earnings function model excluding the three fixed effects and the corresponding coefficient in a regression including them is given by the coefficients on union density in separate regressions of the respective fixed effect on the arguments of the base model. For the nonlinear case, linking the union premium to the extent of worker representation, a generalization of the Gelbach decomposition is applied and summarized in three curves charting the contribution of the three fixed effects.

covered by two or more agreements depending on the union affiliation of the workers (although as a practical matter the content of most of the agreements is similar, the respective tables of wages tending to be the same). The situation may be further stratified if the firm in question straddles more than one line of economic activity, thereby belonging to one or more employer associations. As a result of fragmentation, therefore, several agreements may coexist for the same region, occupation, and firm. Horizontal or occupation-based agreements are also possible, although they are infrequent largely because the law gives precedence to vertical sectoral agreements many of which are signed by a large number of primary unions that may include occupation-based unions.

Portuguese collective agreements are at once both extensive and general. They are extensive insofar as they cover many categories of worker. On average branch agreements have historically set wages for around 100 job titles, or *categoria profissional*. However, the contents are general. Thus, for example, agreements set wage floors and make no attempt to anticipate earnings growth beyond that set by collective bargaining and incorporate such development within the contract (as in countries such as Sweden). As a result, the links between wage growth in Portuguese contracts and the actual economic conditions obtaining at firm level can be very loose, giving the firm freedom of maneuver to tailor remuneration according to its prevailing economic circumstances. Other research has exploited this difference between actual wages and the contract wage – termed the ‘wage cushion’ – to offer an explanation for considerable wage flexibility (and low unemployment) in the past despite institutional structures that *prima facie* might be expected to impart rigidity (see, in particular, Cardoso and Portugal, 2005). In analyzing the role of union density on wages, therefore, our own analysis will reflect not only actual wages but also the (estimated) contractually bargained wage and the difference between the two (the wage cushion). In addition, since Portuguese contracts set other minimum conditions apart from the basic monthly wage level – most typically, allowances for meals, overtime, shifts, and bonuses not having a basis in productivity – our analysis will also investigate the impact of union density on these other components of actual earnings as well.²

The most potent mechanism shaping the formation of wages has traditionally been the systematic extension via so-called *Portarias de Extensão* of industry-wide agreements (and occasionally ACTs) by the Ministry of Employment, following a request from either or both of the parties to the agreement. (Voluntary extensions are also possible, while employers who sign an agreement with a trade union(s) usually extend its application to the entire workforce, irrespective of the worker’s union status.) The upshot of this near

² Until recently, it has been the case that Portuguese collective agreements remain in place until a new agreement is signed. Coupled with the *favor laboris* principle that new agreements should yield more favorable conditions than those they are replacing, this has meant that collective agreements have tended to be revised regularly (and typically on an annual basis) only insofar as wages are concerned, their other terms and conditions often being left untouched for many years. Recent changes in the Portuguese labor code mean that collective agreements can now expire if they are not renewed, although the expiry period is protracted.

automatic procedure is that even those wage agreements reached by trade unions and employers' associations with very low representation have had a strong impact in setting wage floors. As indicated earlier, between 70 and 80 percent of the labor force have benefited from collective agreements without being members of the organizations that signed them. Finally, in the absence of one of the representatives, or in the presence of strategic delays in negotiations/refusals to negotiate, the Ministry of Employment can regulate the sector directly through an Ordinance of Working Conditions, or *Portarias de Condições de Trabalho*. (An arbitration process, either mandatory or voluntary, may be set in motion to unfreeze 'blockages.')

The extension mechanism in conjunction with the large number of job titles set down in the typical sectoral agreement together explain the 30,000 (informal) minimum wages referred to in the title of a very recent analysis of the employment and wage consequences of collective bargaining extensions (Martins, 2014).

In addition to the extension procedure, wage floors are also set under national minimum wage machinery, set up in 1974. The minimum wage can exceed that set under sectoral bargaining. This guaranteed monthly minimum wage or *Retribuição Mínima Mensal Garantida* (RMMG) was virtually stagnant in real terms between 2002 and 2006, leading to an agreement between the social partners (government, the trade union confederations, and the employers' confederation)³ in 2006 allowing for an increase of almost 30 percent, to be phased in over five years and setting a medium-term target value €500 by 2011. It has been estimated that the share of minimum wage earners among full-time workers aged 18 to 61 years rose dramatically from 6.7 percent of total employment in 2006 to 16.6 percent in 2010 (Carneiro, Guimarães, and Portugal, 2012: 451).

As is well known, Portugal was subject to a severe economic crisis in 2011/2013. Both systems of minimum wages – nation-wide and collectively bargained/extended – were disrupted by the crisis. As part of the *Memorandum of Understanding*⁴ concluded between the Portuguese government and the *Troika* in May 2011, it was agreed among other things that the procedures for extending collective agreements would be changed, even prior to which the government committed to restrict the extension of collective agreements.⁵ In October 2012 the government announced new criteria for the administrative extension of

³ Although the last centralized agreement or pact establishing (a reference value for) nation-wide wage increases was in 1996, a number of agreements have been reached in the tripartite Standing Council for Social Concertation, or *Comissão Permanente da Concertação Social*. On the path of social concertation in Portugal, see Palma Ramalho (2013).

⁴ The terms of the *Memorandum* are available at http://economico.sapo.pt/public/uploads/memorandotroika_04-05-2011.pdf.

⁵ Other changes under the *Memorandum* included revisions to the unemployment insurance system in terms of the level and duration of benefits, a diminution in employment protection via a reduction in severance payments and the relaxation of protection against individual dismissals, a reduction in the payment for overtime working and an increase in hours by reducing compensatory time off per hour of overtime, and an expansion of flexible working time arrangements in the form of working time accounts at individual and plant level.

collective agreements taking into account the representativeness of the negotiating organizations and the implication of such extension for non-affiliated firms. Most importantly, agreements could only be extended if at least one union and one employers' organization requested it and the wider signatory organizations employed more than one-half of the employees in the relevant industry. However, in June 2014 this Resolution was modified: the much liberalized criterion is now that the employers' association represents at least 50 percent of employees in the sector, or that its associates must include at least 30 percent of micro, small, and medium companies (employing up to 250 employees). As far as the national minimum wage was concerned, the *Memorandum* proposed to make any increase in the minimum wage conditional on economic and labor market developments. The minimum wage was duly frozen and in 2012 and 2013 it stood at the level of 2011 (viz. €485). It was not updated to €505 – a little above the medium-term target – until October 2014. (However, effective from January 1, 2016, the minimum wage was raised to €530.)

III. The Datasets

The data sources used in this exercise are the *Quadros de Pessoal* (Personnel Tables), 1986-2009, and the *Relatório Único* (Single Report), 2010-2013.⁶ Each longitudinal matched employer-employee-job title database is identical other than in one main respect: the successor survey contains data on the union density of the firm that for the first time permit accurate estimates of union density to be obtained.

Beginning with the *Quadros de Pessoal*, the survey is mandatory in nature and is administered by the Ministry of Employment and Social Security on an annual basis for all establishments with at least one wage earner. All workers employed by the firm in the reference month (March of each year until 1993, October thereafter) are reported, although civil servants and workers in domestic service are not covered while the coverage of agriculture is necessarily spotty because of the importance of the informal sector/ low share of wage earners in agriculture. In short, the entire population of private-sector firms in manufacturing and services with wage earners is covered. Further, by virtue of its mandatory nature, the high response rate in the *Quadros de Pessoal* ensures that problems commonly associated with panel data are much attenuated. This is underscored by the requirement that the data be made publicly available at the place of work.

The dataset reports the firm's location, industry, employment, sales, ownership, and legal basis. Worker information includes gender, age, skill, broad occupation, schooling completed, starting date with the firm, earnings, and working hours. In addition, the survey also records the collective bargaining arrangement and the specific job title held by the worker under collective bargaining.⁷ The wage variable is recorded in considerable detail, indicating the worker's gross monthly earnings (the actual or total wage),

⁶ For the years 1990 and 2001 the *Quadros de Pessoal* database was not administered.

⁷ Those workers not covered by any collective agreement are coded as such (i.e. "non-covered workers"). According to Addison, Portugal, and Vilares (2016), they comprise less than 11 percent of the sample between 2010 and 2013,

which sum is split into the following four components: the base wage (i.e. the gross pay for normal hours of work), overtime pay, and regularly and irregularly paid supplements. Normal monthly hours worked and overtime hours are also reported. Note that for the year 2010 alone, an upgraded version of the dataset distinguishes between the three regularly paid supplements, namely the meals subsidy, shift pay, and other benefits not linked to productivity.

The following restrictions were placed on the data. First, the analysis was confined to full-time employed workers in receipt of what was contractually defined for the reporting month. Second, workers from the agriculture, fisheries, and energy products/extraction sectors were excluded. Third, workers aged less than 18 years and greater than 65 years were excised, as also were those whose monthly wages were less than 80 percent of the mandatory minimum wage (or *RMMG*), corresponding to the lowest admissible wage for apprentices. Finally, observations not belonging to the largest connected group were dropped, amounting to some 1 percent of the total number of observations.⁸

This brings us to the successor *Relatório Único*, initiated in 2010 and ending with the most recently available 2013 wave. As in the later versions of *Quadros de Pessoal*, the database is collected in October of each year. As noted earlier, the key feature of this successor dataset is that it allows us to construct a measure of union density at firm level. Specifically, the survey asks of the manager respondent: “Indicate the number of workers for whom you have knowledge of their membership in a union (because they are union officials, because you deduct membership dues from their salary, or because the worker informed you about his/her membership so as to determine which particular collective regulation is applicable to their case).” The sum total of such workers – whose personal union status is unknown, precluding use of an individual union membership variable – divided by the number of workers employed by the firm provides our measure of union density.

Overall, the joint dataset includes 39,442,324 observations of worker-year pairs, of which 6,814,269 are from the *Relatório Único*. The joint dataset has a basis in the records of 6,326,822 workers, 684,337 firms, 136,094 job-titles, and 11,513,115 matches worker-firm that were followed since 1986. The *Relatório Único* encompasses 2,521,111 workers, 259,832 firms, and 52,657 job-titles, followed between 2010 and 2013.

IV. Modeling

⁸ A connected group links the job title and the firm to the rest of the group such that all the fixed effects are connected. Restricting the analysis to this subset of the data ensures that the estimates of the fixed effects are comparable (see Guimarães and Portugal, 2010).

We next describe the procedures used, firstly, to estimate the union wage gap and, secondly, to account for the component contributions of firm compensation policies, worker ability, and occupational premiums via the estimation of firm, worker, and job-title fixed effects, respectively.

Estimation of the Union Wage Gap

The method used to estimate the union wage gap has three steps. The first estimates a specific intercept for each level of union density. The second offers a (non-linear) semi-parametric treatment of those estimates. The third provides confidence intervals accounting jointly for the disturbances in the estimates and in the semi-parametric treatment considered, via a percentile method bootstrap.

In the first step we estimate a standard Mincerian wage equation, augmented by a union density fixed effect, as follows:

$$\ln y_{i,t} = \mathbf{x}'_{i,t}\beta + \vartheta_u + \delta_t + \varepsilon_{i,t}, \quad (1)$$

here $\ln y_{i,t}$ is natural logarithm of worker compensation,⁹ $\mathbf{x}'_{i,t}$ is a vector of k observed characteristics of the worker and his/her employer, β is a vector of coefficients for the observed characteristics of workers and firms, ϑ_u is a union density fixed effect, δ_t is a set of year dummies, and ε is the error component. The explanatory variables (or observed characteristics) of workers and firms are age, age squared, seniority, seniority squared, and dummies for education, firm size, and industry.

According to equation (1), there are four factors that explain compensation variation:

1. the observed characteristics of workers and firms ($\mathbf{x}'_{i,t}$);
2. a fixed effect for each level of union density at firm level (ϑ_u);
3. a time fixed effect (δ_t); and,
4. a disturbance term ($\varepsilon_{i,t}$), assumed to have the usual properties.

Equation (1) can thus be interpreted as the conditional expectation of compensation of a given worker, accounting for the observed characteristics of his/her employer, the worker's own observed characteristics, and the level of union density at firm level. In this approach, the number of parameters to be estimated is $k + T + U$, as we are considering all the specific intercepts for each level of union density (U).

In the second step, we will estimate a kernel regression linking the estimates of the union density fixed effect and actual union density at firm level:

$$\widehat{\vartheta}_u = \mathcal{F}(\mathbf{U}\mathbf{d}_f) + v_{f,u}, \quad (2)$$

⁹ In addition, for the year 2010 total compensation will be considered alongside the base wage, overtime pay, and three regular wage supplements.

where $\hat{\vartheta}_u$ is the union density fixed effect estimate obtained from the first step, \mathbf{Ud}_f is the prevailing union density of the firm, $v_{f,u}$ is the disturbance term, and $\mathcal{F}(\cdot)$ is a standard Epanechnikov kernel function.¹⁰

The estimation of local weighted union wage gaps results in a smoothed, nonlinear, and semi-parametric estimate of a union wage gap curve. To facilitate the interpretation of the results, a convenient normalization requires that the fixed effect in the absence of workplace unionism be set equal to zero. This assumption implies no further restriction as the union wage gap represents the relative difference in wages for workers at firms with different levels of union density, controlling for the observed characteristics of workers and firms ($\mathbf{x}'_{i,t}$). The estimate $\widehat{\vartheta}_u$ represents a different intercept in each worker's wage equation. Thus, in the second step of the procedure, we allow firms to contribute to the kernel function via their number of workers, so that each firm carries implicitly a different weight in the estimation according to its size.

Concurrently, a simplified version of this model can be estimated by OLS using a standard OLS approach in which a single slope for the effect of union density replaces specific intercepts for each level of union density, as follows:

$$\ln y_{i,t} = \mathbf{x}'_{i,t}\beta + \mathbf{Ud}_f\gamma + \delta_t + \varepsilon_{i,t}, \quad (3)$$

where \mathbf{Ud}_f is the level of union density of the employer, and γ is the coefficient associated with the level of union density. As a means of benchmarking, and as a way of demonstrating the usefulness of the three-step model, this linearization will form the starting point in what follows.¹¹ In the third and final step of this procedure, we provide a method of estimating local standard errors at each existing level of union density in the dataset, corresponding to each specific estimate of the fixed effect. Given the two previous steps of this computation, to be valid the standard errors should reflect the role of the disturbance arising from the estimation of the fixed effects per se, that resulting from the kernel smoothed estimate, and the possible covariance structure between each. To fulfill those requirements jointly, without any parametric assumption as to the variance-covariance matrix of the two disturbance terms, we rely on the bootstrap method proposed by Efron (1979).

¹⁰ According to the standard methodology of the Kernel function, the Epanechnikov kernel function can be described as:

$$\mathcal{F}(z) = \frac{1}{2Nh^*} \sum_{i=1}^N \frac{3}{4} \left[\left(1 - \left(\frac{z_i - z_0}{h} \right)^2 \right) \times \mathbf{1} \left(\left| \frac{z_i - z_0}{h} \right| < 1 \right) \right], \quad \mathbf{1}(\mathbf{A}) = \begin{cases} 1 & \text{if } \mathbf{A} \text{ occurs,} \\ 0 & \text{otherwise} \end{cases}$$

where N is the number of workers in the sample, and h^* is Silverman's plug-in estimate. Note that we have considered a transformation of the Epanechnikov kernel function to account for the doubling of Silverman's plug-in estimate. A discussion of the classical tension between the potential bias and the smoothness of the curve is presented by Cameron and Trivedi (2005), who also show that choice of the particular kernel function does not significantly alter the results.

¹¹ In producing this benchmark, we will consider variations in the set of included observed characteristics. Apart from the the standard set described, we will consider an alternative specification that excludes the observed characteristics of firms and the education dummies, and another that simply omits out the former.

In this light, we produce 2,000 bootstrap samples (i.e. samples with replacement) based on the dataset considered. In each of these we performed steps one and two, obtaining a vector $\boldsymbol{\theta}_u^*$ of 2,000 smoothed estimates for each existing level of union density. A local confidence interval (i.e. for each level of union density) can then be defined by computing the $(\frac{\alpha}{2})$ and $(1 - \frac{\alpha}{2})$ percentiles of the distribution of each $\boldsymbol{\theta}_u^*$. By linking the estimates of each percentile over the levels of union density, we generate two smoothed, nonlinear and semi-parametric estimates that comprise the bounds of the confidence interval of the estimated union wage gap curve, and yield the following confidence interval:

$$\left(\mathcal{F}(\mathbf{Ud}_f)_{\frac{\alpha}{2}}; \mathcal{F}(\mathbf{Ud}_f)_{1-\frac{\alpha}{2}} \right) = \left(\boldsymbol{\theta}_{u,\frac{\alpha}{2}}^*; \boldsymbol{\theta}_{u,1-\frac{\alpha}{2}}^* \right). \quad (4)$$

Estimation of the Sources of the Union Wage Gap

Given the estimate of the union wage gap ($\widehat{\vartheta}_u$), it is useful to decompose this outcome measure into its constituent mechanisms, namely to identify the contributions of worker, firm, and job-title time-invariant heterogeneity. To this end, we adopt the conditional decomposition of Gelbach (2014).

For purposes of benchmarking, we provide the decomposition for the standard OLS approach¹². Thus, as a full-specification model, we include in equation (3) the sources of time-invariant heterogeneity exploiting the methodology first introduced in Carneiro, Guimarães, and Portugal (2012). The model thus becomes:

$$\ln y_{i,t} = \mathbf{x}'_{i,t} \tilde{\boldsymbol{\beta}} + \mathbf{Ud}_f \tilde{\gamma} + \alpha_i + \lambda_f + \theta_j + \delta_t + \varepsilon_{i,t}, \quad (5)$$

Following Gelbach (2016), consider equation (3) as the base model, whose union wage gap we intend to decompose, and take as the full specification the model in equation (5). It is shown that the difference between the coefficients in the base and full models is given by:

$$\hat{\boldsymbol{\beta}} - \hat{\tilde{\boldsymbol{\beta}}} = \mathbf{P}_X \widehat{\boldsymbol{\beta}}_\alpha + \mathbf{P}_X \widehat{\boldsymbol{\beta}}_\lambda + \mathbf{P}_X \widehat{\boldsymbol{\beta}}_\theta, \quad (6)$$

where $\mathbf{P}_X = (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'$. This implies that the terms on the right-hand side of equation (6) are the coefficients of three regressions that regress the estimate of the pertinent fixed effect on the controls of equation (3). Focusing on the coefficients attaching to the union density variable, we have:

$$\hat{\gamma} - \hat{\tilde{\gamma}} = \widehat{\gamma}_\alpha + \widehat{\gamma}_\lambda + \widehat{\gamma}_\theta, \quad (7)$$

which yields an exact, unambiguous and conditional decomposition of the union wage gap into its worker, firm, and job-title time-invariant components.

¹² This decomposition will be replicated for each set of observed characteristics considered in our benchmark exercise described previously. In the interests of expositional clarity, we shall describe the method for one arbitrary set of controls throughout.

Similarly, we can apply the same principle of the Gelbach decomposition to the union wage gap *curve* obtained in equation (1). For that purpose, consider equation (1) as the base model, and its expansion to incorporate the fixed effects as the full specification. Accordingly, the latter can be written:

$$\ln y_{i,t} = \mathbf{x}'_{i,t} \tilde{\beta} + \tilde{\vartheta}_u + \alpha_i + \lambda_f + \theta_j + \delta_t + \varepsilon_{i,t}. \quad (8)$$

Analogously to the result obtained in equations (6) and (7), we verify that the difference between the union density fixed effect of the full and base models – equations (8) and (1), respectively – can be decomposed into three fixed effects. This is achieved by estimating three auxiliary fixed effect models in which the worker, firm, and job-title fixed effects become the independent variables and the regressors match those of the base model, as follows:

$$\hat{\vartheta} - \hat{\vartheta} = \widehat{\vartheta}_\alpha + \widehat{\vartheta}_\lambda + \widehat{\vartheta}_\theta. \quad (9)$$

Then, by smoothing these estimates, not only are we able unambiguously to decompose the union density fixed effect but also the union wage gap curve as well.

V. Main Findings

The Union Wage Gap Curve for Total Earnings

In Portugal the evidence of wage differentials due to a firm's degree of unionization is palpable. For example, the heuristic distributions of the logarithm of total hourly wages shown in Figure 1 evince meaningful differences in both shape and mean when more and less unionized workplaces are considered. Following an OLS approach, as described in equation (3), consistent evidence of strong union wage differentials is also found. If we account for the most parsimonious set of regressors (namely gender, age and tenure, as described in section IV) the union differential reaches 88.7 percent $[(e^{0.635} - 1) \cdot 100]$. This estimate falls to just 52.4 percent $[(e^{0.422} - 1) \cdot 100]$ if the set of controls is enlarged to include the worker's education, that is, with all observed worker characteristics now included. Table 1 provides the results of estimating a more reliable measure of the union wage gap for Portugal, namely after controlling for the full set of observed worker and firm characteristics, again as described in section IV. The gap is some 15.4 percent $[(e^{0.144} - 1) \cdot 100]$, which is again indicative of a sizable union wage differential (and on a par with or exceeding U.S. estimates).¹³

(Figure 2 and Table 1 near here)

¹³ See the early studies of Blanchflower and Bryson (2003), and Hirsch (2004); and, especially, the more recent plant-level studies of Frandsen (2012), and Lee and Mas (2012).

This wage differential is to be interpreted in the following way: it represents the wage difference/gap between two identical workers, one of whom is employed in a fully unionized firm and the other in an otherwise identical non-unionized firm. Moreover, this methodology implies that the value of the union wage gap for each point in the continuum of union density is determined by and conforms to a linear relationship. However, an important issue is whether the marginal change in the union wage gap is in fact the same when a newly unionized worker joins a union-free workforce as opposed to one in which a large plurality of workers are organized. In seeking to estimate a union wage gap without assuming constant marginal effects throughout, we shall follow the methodology described earlier to estimate the union wage gap *curve*. This estimate is shown in Figure 2. It demonstrates that the linear approach is misleading. In particular, unions need some critical mass (of unionized workers) in order to influence wages materially. That is to say, only above some threshold – somewhat in excess of 20 percent – do higher levels of unionism feed through into increasing union wage gaps. The premium peaks at approximately 18 percent for levels of unionization of around 70 percent, after which point we observe a relatively modest decline.

(Figure 2 near here)

A plausible explanation for the shape of the fitted curve relies on the idea that the bargaining power of a union is a function of its ability to credibly threaten the employer through a withdrawal of labor (e.g. Farber, 1986). Moreover, conventional models of the union depict the union objective as one of seeking to increase wages (or the firm's payroll), subject to maintaining the firm intact or its being able to earn some minimum acceptable profit level. It is reasonable to assume that unions need some minimum complement of unionized workers to effectively impose costs on the employer in the event of a failure to agree. With a preponderance of the workforce organized, the capability to impose a total shutdown is implied, such that further increases in union density are not to be equated with higher union wage premia.

Union Wage Gap Curves by Component of Total Earnings

The total monthly compensation of a worker can be divided into several components. One part of a worker's compensation is a function of working time and the work schedule. Thus, the worker receives a fixed monthly wage (the base wage), namely monthly compensation for the normal work period. As appropriate, there are also overtime or shift payments. Beyond these components, workers are commonly entitled to fringe benefits. For example, by law a worker is entitled to a fixed daily meals allowance for each day worked. Additionally, there are other more diffuse regular fixed fringe benefits, which may include a job seniority bonus (*diuturnidades*), employer contributions to employees' private pension plans, health insurance, and even child allowances. On top of regular compensation, workers may also be entitled to productivity bonuses that are ordinarily distributed once a year.

For 2010, which is the only year for which we have detailed information on these categories, we may construct a series of union wage gap curves for the various components of a worker's regular

compensation, using the methodology used previously. Five such additional curves are constructed in Figure 3. Our breakdown of monthly compensation distinguishes between the base wage, overtime pay, shift pay, the meals subsidy, and other regular fringe benefits received. The wage gap for the total wage, described earlier, is broadly supported by the pattern of differentials obtaining for each component of the worker's regular compensation, but it is elevated in the case of fringe benefits that are not related to working time. In a material sense, these payments are the same for a sizable share of workers in the firm, irrespective of their job title. For example, the meals subsidy is often of equal amount per worker, while the tenure-related payments that represent a major share of the other regular benefits are more a function of tenure than of job-title.

(Figure 3 near here)

As far as the share of compensation linked to working time and the work schedule is concerned, it is noticeable that both elements contribute to a reduction in the union wage gap soon after or even before union density extends to the majority of the workforce. By comparison with the fringe benefits unrelated to working time, this latter tendency suggests a union preference away from working-time related compensation toward non-working-time related compensation. Thus, when capable of exerting a meaningful influence on the firm's compensation policy, unions seemingly prefer to acquire sizable wage differentials in those components of compensation that by default are equal for every worker, even as they countenance a reduction of wage gaps in the other components of compensation. This finding is consistent with the canonical evidence that wage differentials for variables such as age and education are smaller in more heavily unionized environments.

Furthermore, this reshuffling of the firm's compensation policy is likely not unrelated to the tax environment. For the United States, Felix and Hines (2009) have reported that unions and firms take taxation into account in their negotiations, in effect bargaining over the distribution of potential tax savings. Portuguese tax policy has typically favored certain fringe benefits over wages. Even if this more favorable tax treatment¹⁴ has been diluted in the contemporary era of crises, it has served to pull the bargaining parties in a direction allowing for tax optimization on the part of firms. Therefore, as Rees (1968) noted long ago, unionization and preferable tax treatment are engines behind the increasing share of private supplements in workers' compensation.

The Sources of the Union Wage Gap for Total Earnings

The sizable union wage gap for total earnings that we have estimated constitutes an average differential between the wages of two observationally identical workers in two observationally identical firms with

¹⁴ For example, the meals subsidy is not taxed below a certain daily rate while private health insurance plans and private retirement schemes that complement social security are subject to special exemptions.

distinct levels of unionization. A key question concerns the potential sources of the unobserved heterogeneity behind these differentials. We next consider how worker sorting among firms with different compensation policies, how the compensation tables of workers are defined, and how the allocation of workers with different unobserved ability drives the union wage gap.

In principle, the conditional influence (i.e. accounting for observables) of unions on earnings compensation can arise from other sources, but as a practical matter we find that after accounting for firm, worker, and job-title fixed effects the portion of the union wage gap remaining to be explained is vestigial. This is the case for both the linear approach and the fitted union wage gap curve. Our focus in decomposing the union wage gap is therefore upon the contributions of each of these three sources of unobserved heterogeneity. In what follows, the major difference between the two (decomposition) approaches resides in the flexibility of the estimates, offering improved estimation of the union wage gap curve vis-à-vis the restrictive linear approach.

Before proceeding with the decomposition strategy, it is useful to discuss the background to the three high-dimensional fixed effects added in equation (5). In this exercise, it is important to recognize that their interpretation hinges on the type of wage that is being considered. At this stage, we will focus on interpreting the fixed effects as they pertain to total compensation. Later in the discussion, we will revisit this point in considering other types of compensation.

The job-title corresponds to the worker's assigned occupation in the firm, as defined in the collective agreement governing the employment relationship. This defined occupation for bargaining purposes basically sets the floors for the various components of compensation that the worker is legally entitled to receive. Ordinarily, these floors include in addition to the base wage, a meals subsidy, a job seniority bonus, and compensation related to working time such as overtime pay or shift bonuses. On rare occasions, they may also prescribe obligations of the firm in respect of other fringe benefits, such as health insurance.

Thus, the job-title fixed effect condenses the influence of the compensation floor defined for each worker. Note that under this definition of job-title, two workers with the same job description (i.e. performing the same tasks and having the same responsibilities) covered by different bargaining arrangements will often have different job-titles. There results a (very) disaggregated set of occupations (around 30,000 according to Martins, 2014), when every collective bargaining instrument is considered. The inclusion of job-title fixed effects may be viewed as building upon a first generation Mincerian wage equation that encompasses a broad definition of job descriptions. In the current setup, we provide an unusually fine accounting of the tasks required to fill a job (i.e. job descriptions), and we link those job-descriptions to the relevant collective instrument to fully define an occupation.

Panel A of Figure 4 shows the empirical distribution of the job-title fixed effects, contrasting workers in a high union density firms with their counterparts in low density firms. (The values of less than/more than 10 percent union density roughly delineate to below/above densities.) The distributions do not exhibit discernible differences by union density, suggesting that the impact of the legal compensation floors have a minor influence on the total compensation that the worker actually receives. Either there are no differences in the floors between more unionized and less unionized firms or, in the presence of such differentials, the link to the total compensation is somehow broken.

For its part, the firm fixed effect, in essence, captures the (constant) wage policy of the firm, constrained by the minimum legal requirements defined under collective bargaining, which are fully captured by the previously discussed job-title fixed effect. Firms with generous compensation policies will exhibit positive firm fixed effects, while firms with compensation policies close to the minimum requirements will generate negative fixed effects. In a later stage of our discussion we will decompose this fixed effect to reflect the two major decisions the firm will ordinarily make, namely where to place the worker in the compensation tables defined under the collective agreement and whether or not to raise the compensation received by the workers above the defined floors. In sum, the firm fixed effect represents the overall stance of the firm regarding the compensation of the worker, expressed through these two mechanisms. In Panel B of Figure 4 we again contrast the distribution of the firm fixed effects for workers in a high and low density firms.¹⁵ It is very clear from the distributions that high density firms disproportionately populate high-paying firms – even if we cannot say whether this is the outcome of a pure sorting strategy on the part of the trade unions or instead the direct expression of union power.

(Figure 4 near here)

Finally, Panel C of Figure 4 presents the empirical distribution of the worker fixed-effects. These worker fixed effects condense the influence of constant characteristics (both observed and non-observed) of individuals on their wages. They are basically a proxy for the portable human capital (or productivity) of the worker. The picture is one in which highly unionized firms appear to employ relatively more skilled individuals. This outcome can be the result of observed characteristics (e.g. schooling or gender) or unobserved factors (e.g. ability), and we shall subsequently address the specific role of unobserved skills.

Table 2 next presents the results for the Gelbach decomposition of the linear specification. The coefficient estimate contained in the first column of the table simply recalls the estimated union wage gap (of 14.4 log points) obtained from equation (3) and reported earlier in Table 1. The estimated union wage gap, after the inclusion of the three high dimensional fixed effects (equation (5)), is given in the second

¹⁵ Observe, however, that in this comparison the influence of variables such as industry or firm size is still subsumed in the firm fixed effect. The subsequent Gelbach decomposition will enable us to filter out the impact of the firm fixed effect on the wage gap from the variable included in the benchmark specification.

column of the table (-0.2 log points). The third column provides the contribution of each fixed effect to the change in the estimation of the union wage gap (equation (7)).¹⁶ By construction, this decomposition is both exact, the sum of the contributions corresponding to the difference between the two union wage gap estimates, and unambiguous. Evidently, a large fraction of the union wage gap is explained by the heterogeneity of firms' compensation policies. After accounting for the observable characteristics of the worker and the firm, the constant unobserved characteristics of workers, and the process of job-title definition (under the collective agreement), the allocation of workers into firms is responsible for 13.4 log points of the union wage gap of some 14.4 log points. Put differently, if workers were randomly assigned to firms, the union wage gap would be reduced by about 93 percent. Further, we find that compensation floors modestly impact the union wage gap; contributing 1.6 log points – or another 11 percent – of the estimated union wage gap.

(Table 2 near here)

Finally, there is no evidence pointing to any other meaningful source of the union wage gap. As regards the worker dimension, and after accounting for workers' observable traits, those individuals working in a fully-unionized firm receive a permanent compensation for their unobserved characteristics that is estimated to be just 0.42 log points lower than in the case of a non-unionized firm. Indeed, we are unable to reject the hypothesis that their allocation does not differ from what would emerge from random assignment to firms (and consequently to degree of unionization).

Given the latter finding, one might be misled into concluding that the worker dimension is absent from the process of wage differential formation. In taking a closer look at the sources of the union wage gap, it is useful to return to the rawest measures presented thus far, namely those that do not fully account for the observed characteristics of workers and firms. In this procedure we shall rely on the unambiguity property of the Gelbach decomposition to ensure that the abnormal increase in the unobservable component will still be properly determined and assigned to the relevant unobserved dimension – be it a firm, job-title, or worker effect. The findings are described in Table 3.

(Table 3 near here)

When one considers a minimal set of observables (i.e. age, tenure, and gender), it can be seen from the bottom panel of Table 3 that the contribution of the firm dimension to the union wage differential is reduced to three-fourths (from the 93 percent in our benchmark case), while the job-title component is of unchanged relative importance. The remaining share of around 15 percent of the estimated differential is now captured by the worker fixed effect, which differs from the previously-estimated share by including

¹⁶ In practice, in the current framework, the application of the Gelbach decomposition simply translates into running three auxiliary OLS regressions identical to equation (3), but where the dependent variable is successively replaced by the corresponding estimated fixed effects.

education as a component of the unobserved heterogeneity of workers. This new allocation of heterogeneity underscores a key stylized fact: more highly unionized environments tend to react to the erection of wage differentials by partially offsetting them through the recruitment of more educated workers. While our findings do not therefore point to an unbalanced allocation of workers to union density levels in what concerns their unobserved (to the researcher) attributes, this does not mean that there is no selection of workers into different degrees of unionization. Rather, the ‘effect’ of unions is both observable and standard, operating through selection by education levels.

This finding is consistent even if the previous Gelbach decomposition is estimated with the inclusion of education levels as observed controls. As can be seen from the middle panel of Table 3, the importance of worker unobserved heterogeneity is sharply reduced to 0.007 log points. In this very exercise the importance of firm observables rises dramatically; yielding a 28 log point breach between this estimate of the wage differential and our proposed estimate in the top panel of the table. This result is intimately related to union ‘location.’ As demonstrated by Addison, Portugal, and Vilares (2016), unions tend to gravitate toward larger firms in specific sectors. Note that these are precisely the observed firm characteristics that have been remitted to the unobserved component in the present exercise.

Lastly, from Figure 5 it can be seen that the estimates of the Gelbach decomposition of the union *wage gap curve* obtained from equations (8) and (9) broadly confirm the principal result of the OLS approach, namely the leading role reserved for the compensation policies of firms, while providing a more informative picture of the sources of the union wage gap. In particular, the assignment of job titles to workers reveals that there is a zone or a relevant region of densities (broadly between 50 to 70 percent) where its contribution to the gap is more sizable, reaching almost 4 log points. Once again, the limitations attaching to the linearity property are evident, most notably in respect of highly unionized firms.

(Figure 5 near here)

The Sources of the Union Wage Gap, Bargained Wages, and the Wage Cushion

The bargained wage is the base wage floor given in the worker’s contract, and therefore corresponds to one of the compensation floors in the collective agreement, albeit the most important one given its contribution to total compensation.¹⁷ For its part, the *wage cushion* corresponds to the ratio between the total and the

¹⁷ Following the methodology proposed in Cardoso and Portugal (2005), the bargained wage is defined as the mode of the base wage within each year and job-title. Having documented contractual wages for three industries employing around 10 percent of full-time workers in manufacturing and services, these authors show that the mode of the wage distribution of the base wage for each worker category within each collective agreement matches quite well the mandatory floors for each job-title at collective bargaining level.

bargained wage, such that the logarithm of total compensation is the sum of the logarithms of the bargained wage and the wage cushion.¹⁸

Therefore, the analysis of total compensation as the sum of a base wage floor (i.e. bargained wage) that has mandatorily to be paid to the worker and fringe benefits, where the differential between the actual base wage and its base wage floor itself corresponds for our purposes to a particular form of fringe benefit, facilitates comparisons between regimes.¹⁹ With respect to fringe benefits in general, either the firm is subjected to mandatory wage floors (and may decide to pay at those floor levels or improve upon them) or it may decide to provide the workers non-regulated fringe benefits in the absence of a concrete obligation. Notice that we are not claiming a full partition between the mandatory component and the flexible component of compensation, instead we are simply distinguishing between the base wage floor and all fringe benefits, including the difference between the base wage and the base wage floor.

Turning to the wage cushion, differentials in this measure between two workers have important scale properties that is convenient to separate out. Observe that by construction the sum of the bargained wage and wage cushion differentials equals the total compensation differential. Further, recall that the bargained wage plus fringe benefits, as defined, correspond to the total wage. In consequence, whenever there exists a differential in the bargained wage between two workers, the wage cushion equivalent will take a zero value if and only if the bargained wage differential equals their total compensation differential. And this will only occur if the fringe benefit component records exactly the same differential; that is, a complete pass through with each pay component registering the same percentage difference. By the same token, were the wage cushion and bargained wage differentials to be of different sign, the implication would be that fringe benefits were used to attenuate the latter differential, so that total compensation would display a lower wage differential. Depending on the magnitudes, this result could eventuate from either a smaller percentage increase in the fringe benefit component or even a lower level of fringe benefits in the case of the worker enjoying the higher bargained wage. If the wage cushion differential is of the same sign as the bargained wage differential, it potentiates the effect of the former, meaning that the differential in fringe benefits has to be higher in absolute value than that recorded at bargained wage level.

In our context, a useful way to look at this setting is first to think of an artificial framework in which all workers collect the bargained wage corresponding to their job titles and no more – a direct result of the bargaining between unions and firms, enshrined in law and a such the mandatory component of base wages.

¹⁸ That is, $W_{Total} = W_{Bargain} \times \frac{W_{Total}}{W_{Bargain}} = W_{Bargain} \times W_{cushion}$. After a logarithmic transformation, we have $\log(W_{Total}) = \log(W_{Bargain}) + \log(W_{cushion})$.

¹⁹ Given the heterogeneity of collective bargaining compensation floors, which differ from one collective agreement to another, the base wage floors by virtue of being the biggest component of pay, at least constitute some minimal common feature across instruments, allowing comparisons to be drawn.

Then, in a second stage, firms decide on the size of the wage cushion to be paid above by the bargained thresholds, which as discussed earlier includes all fringes. This two-layered system of wage setting is represented in our linear specification estimates of the union wage gap for the bargained wage and the wage cushion, summarized in the first column of Table 4. In fact, we report evidence of union wage gaps for both components of total compensation. But note that they are of distinct sign: the estimated gap in the case of bargained wages amounts to 28.6 log points, while that for the wage cushion is -14.2 log points. Accordingly, the sum of the two wage gaps yields the indicated union wage gap for total compensation of 14.4 log points.

(Table 4 near here)

Similar results are obtained when union wage gap *curves* are estimated. Here the union wage gap curve of the bargained wage attains levels of around 35 percent when the large majority of the workforce is unionized, while the corresponding curve of the wage cushion declines up to minus 12 percent. The union wage gap curves estimated for the bargained wage and the wage cushion reinforce the evidence that unions have a growing effect on compensation policies until the large majority of workers is unionized, after which point that ability is curtailed. These results are summarized in Figure 6.

(Figure 6 near here)

The sizable union wage gap of the bargained wage is not surprising, as unions naturally seek to lock in a significant share of their gains through mandatory dispositions of the collective agreements. Where the constituents of the collective agreement are highly unionized firms, signifying enhanced union bargaining power, unions may be expected to succeed in securing higher base wage floors. In response, firms have some discretion to adjust fringe benefits provided that they meet the prescribed minima for each component benefit. Our results in the form of a negative union wage cushion gap of -14.2 log points do indeed suggest that the wage cushion is deployed to attenuate the bargained wage gap. It follows that the union wage gap for total compensation is lower than that for the bargained wage. To repeat, this compression may result from either a lower percentage gap in the fringe benefits component or by an actual reversion of that gap (now benefiting the worker with a lower bargained wage). The bottom line is that there is a partial offset of the differential in the base wage floor in total compensation, operating through fringe benefits. By the same token, a sizable union wage gap for total compensation still remains.

Before turning to the Gelbach decomposition, observe that the fixed effects calculated where the bargained wage (as opposed to total compensation) is the dependent variable now has slightly different interpretation. Here the bargained wage for a given job description will be same to every firm signing the same collective agreement. As a result, the job-title fixed effect will capture the heterogeneity in the table of base wage floors between firms with *different* collective agreements. It will therefore capture the effect of different levels of the average union density of the firms signing a given collective agreement on base

wage floors.²⁰ As far as the the firm fixed effect is concerned, this will represent the idiosyncratic decision of the firm in assigning a given worker to a specific position in the table of bargained wages, subject to certain natural limits. Thus, the firm fixed effect captures the idiosyncratic decisions of firms on how to position workers in the wage tables according to their degree of workplace union density. For its part, the worker fixed effect represents the allocation mechanism, based on workers' unobservables, to the base wage floors.

In somewhat finer detail, we see that the Gelbach decomposition of the bargained wage (shown in the second panel of Table 4) illustrates the major and equally-sized roles of firm and job-title fixed effects in determining the bargained wage union wage gap. First, through the job-title fixed effect, it reveals the ability of unions to push for higher mandatory wage floors in sectoral agreements that on average represent more unionized firms.²¹ Second, it signals, through the firm fixed effect, that in more unionized firms the worker has access to and is slotted into a job title that prescribes a higher base wage floor. Furthermore, the tiny contribution of worker permanent heterogeneity in the creation of the union wage gap for the bargained wage is as expected, given the largely sectoral setting in which the bargained wage is determined. In short, the union wage gap for the bargained wage corresponds to: (a) the heightened mandatory base wage floors in more highly unionized regimes (i.e. where the average union density of the collective bargaining agreement is higher) and (b) the sorting of workers among job-titles with higher floors in response to higher union density at firm level.

Gelbach decomposition of the wage cushion allows us to reconcile the influence of unions on the bargained wage on the one hand with their effects on total compensation on the other. In particular, we can estimate the size of the offset in fringe benefits attendant upon the setting of higher base wage floors, having partialled out the sorting decisions of firms regarding workers and their job-titles (i.e. the firm-fixed effect). Using the linear procedure (Table 4), we estimate that the effect of unions on the bargained wage via the job-title mechanism is strongly offset via fringe benefits. Specifically, the estimated 16.9 log point differential for the bargained wage derived from the heterogeneity in the job-title framework corresponds to a reduction in the wage cushion of 17.0 log points.

Therefore, a highly unionized regime yields a 16.9 log point difference in the base wage floors vis-à-vis a low unionized regime, but this is almost offset by a reduction of similar magnitude in the average fringe benefits paid by the former agreement. Accordingly, the average total compensation of the two

²⁰ Note that given the firm and the worker fixed effects are included in the estimation, this comparison is made between two identical workers in two identical firms with different levels of union density.

²¹ Note that the sectoral agreements are signed at a much finer definition of sectors than can be captured by our sectoral dummies. Thus, the observed sectors' within heterogeneity is captured by the unobserved heterogeneity of the job title, as it results from the signing of collective agreements with different prescribed tables of base wage floors.

agreements is virtually identical. Intuitively, more highly unionized agreements display higher wage floors and lower levels of fringe benefits.

Having discussed the effects of union density at the collective agreement level, we now turn to consider the firm's implementation of collective bargaining. A more unionized firm may be seen as building on the bargaining process by placing its workers more favorably in the bargained wage tables. This behavior is revealed by the 15.5 log point differential arising from the firm fixed effect of the bargained wage. It is not undone at fringe benefit level as is the case for the average contract of the collective agreement; observe that the corresponding estimate of the firm fixed effect for wage cushion is zero. The suggestion is therefore that the more unionized firm tends to increase fringes in the same proportion as the increase in the base wage floor, so that total compensation also increases in the same percentage.

In sum, workers in *more unionized collective bargaining agreements* experience base wage floors that are elevated, but fringes that are correspondingly reduced, so that total compensation is only modestly altered by collective agreements. However, workers in *more unionized firms* covered by that agreement are better placed in its wage tables and also enjoy higher fringes, resulting in our estimation of the material union wage gap reported for total compensation.

Causality between Unionism and Wage Differentials

The issue of causation attends most discussions of the union premium by reason of omitted variable bias and the endogeneity of unionization – often accompanied by concerns over the representativeness of the study population. Our own analysis is not free of aspects of this controversy since the evidence of sizable wage premia does not establish a causal link between bargaining power and wages. There is, then, an issue of reverse causality if unions seek out firms with more generous compensation policies to begin with or locate in those firms that are more permeable to unions' demands. More specifically, ambiguity is not lacking from the firm fixed effect, and even if no such issues arise in the case of worker heterogeneity or (to a lesser extent) job-title fixed effects as sources of the union wage gap their contributions are of secondary importance. Accordingly, although we know a great deal about union influence in constraining firms in their design of wage policies from our analysis of the decomposition of total compensation and the wage gap, we are perhaps on firmest ground in treating the firm-fixed effect component as establishing an upper bound to the true effect of unions on compensation from this source. That said, we feel no need to cede ground to the claim that a regression discontinuity approach even if it were possible in the Portuguese case (where representation elections do not take place) would provide more convincing/much lower estimates of the union premium. Here we take comfort in the finding by Lee and Mas (2012) to the effect that cumulative abnormal returns in union election wins are much more negative (i.e. the stock market effect is more severe) where the vote share in support of a union is strong. That said, further investigation of the role of the wage policies of the firms is warranted along the gradient of the wage gap profile.

VI. A Robustness Issue: The Role of Match Quality

The recent literature has devoted much attention to the issue of the match between firms and workers, in a discussion that extends well beyond the effect of the heterogeneity of each dimension. This growing line of research (for a survey, see Torres et al., 2015) focuses on the possibility of assortative matching, with higher quality workers forming a match with high-paying firms. Permanent synergies (or, conceivably, antagonisms) may arise in these “*marriages*,” resulting in a mismeasurement of worker and firm heterogeneity if these are taken separately. Controversy has arisen as to whether assortative matching can be directly revealed in a wage equation, but this disputation does not affect the construction of the union wage gap since it is defined as the wage differential between two observably identical workers in two observably identical firms, and is constructed without fixed effects. Nevertheless, it remains germane whether the degree of unionization at firm level affects the match between workers and firms, and thereby leads to mismeasurement of the components of the union wage gap for total compensation.

To tackle this issue, we next perform a Gelbach decomposition in which the components are reduced to job-title heterogeneity and match heterogeneity, the latter functioning as a composite term combining worker (α_i) and firm fixed effects (λ_f) and their interaction (τ_{if}). Therefore, equation (3) becomes:

$$y_{i,t} = \mathbf{x}'_{i,t}\tilde{\beta} + \mathbf{U}\mathbf{d}_f\tilde{\gamma} + \mu_{if} + \theta_j + \delta_t + \varepsilon_{i,t}, \quad (9)$$

where μ_{if} is the match fixed effect ($\mu_{if} = \alpha_i + \lambda_f + \tau_{if}$). In this case, the main result of the Gelbach decomposition becomes:

$$\hat{\gamma} - \hat{\tilde{\gamma}} = \widehat{\gamma}_{if} + \widehat{\gamma}_{\theta}. \quad (10)$$

The same principle may be applied to the decomposition of the union wage gap curves, where the full-specification model, comparable to equation (7), becomes

$$y_{i,t} = \mathbf{x}'_{i,t}\tilde{\beta} + \tilde{\vartheta}_u + \mu_{if} + \theta_j + \delta_t + \varepsilon_{i,t}, \quad (11)$$

while the decomposition holds as

$$\hat{\vartheta} - \hat{\tilde{\vartheta}} = \widehat{\vartheta}_{if} + \widehat{\vartheta}_{\theta}. \quad (12)$$

The results of the Gelbach decomposition for both the linear approach and the union wage gap curve are summarized in Table 5 and Figure 7, respectively.

(Table 5 and Figure 7 near here)

Theoretically, with the inclusion of the job match term, the potential sources of the union wage gap include not only the job-title and worker and firm components but also the quality of the match between

worker and firm. Econometrically, the inclusion of this worker-firm match fixed effect implies the joint estimation of the last three of the above potential sources of the union wage gap. This in turn requires a specific means of comparing the estimates from the standard approach and this new approach in recognition of the fact that the inclusion of firm, worker and firm-worker fixed effects is not feasible by reason of the collinearity among those variables.²²

Given this econometric issue, an adequate way to make a comparison between the standard methodology and an exercise seeking to account for the worker-firm match is via an analysis of that portion of the union wage gap that remains to be explained after partialing out the explicitly considered sources. This is precisely the realm of the of the full model coefficients; specifically, the $\widetilde{\vartheta}_u$ term in equation (7) for the standard decomposition and in equation (12) for the decomposition including the worker-firm match fixed effect. That is to say, the change in the joint capacity of the explicit sources in explaining the union wage gap is due to the inclusion of new sources: in this exercise, the quality of the worker-firm match. Everything else equal, the change recorded in the full model coefficient will fully capture the contribution of the worker-firm match quality to the union wage gap.

Specifically, in the case of the linear approach the change in the full model coefficient, when comparing the standard linear decomposition (Table 2) and the decomposition including the match term (Table 5) is around 0.3 log points, which value will bound the true contribution of the change in the quality of the match to the union wage gap. Similarly, the graphical representation in Figures 5 and 7 of the curves of the full model coefficients corresponding to equations (8) and (12) confirms this finding. *Vulgo*: there is no obvious indication that assortative matching plays a meaningful role in accounting for the union wage gap in total compensation in contrast to its role in the explanation of earnings variation more generally.

VII. Conclusions

This paper offers the first definitive estimates of the union wage gap for Portugal, using linear and nonlinear models. In a situation where approximately 90 percent of workers are covered by collective agreements but only 11 percent of them belong to unions, the key union indicator is union density at firm level. We provide estimates of the union wage gap for total monthly earnings, the bargained wage, and the wage cushion. We also investigate the union wage gap by component of compensation, distinguishing between the base wage, regular wage supplements, and working-time related payments. Having provided estimates of the various wage gaps, the second key contribution of the paper has been to consider their sources. Our three-fixed effects model considers the contribution of worker productivity, the occupational distribution of workers,

²² For a detailed discussion about how to deal with this issue, see Figueiredo, Guimarães, and Woodward (2014); Raposo, Portugal, and Carneiro (2015).

and the wage policies of firms to the wage gap. That is, the analysis accommodates worker heterogeneity, job-title heterogeneity (as reflected in wage tables), and unionized firms adjusting their compensation policies and human resources practices, either voluntarily or in response to union bargaining power. Central to our being able to establish the relative importance of the sources of the union wage gap, apart from the use of large matched employer-employee data sets and appropriate econometric techniques, is Gelbach's (2016) decomposition based on the formula for omitted variable bias.

What do we find? In the first place, there is evidence of a fairly substantial union premium. The union wage gap for total weekly earnings is increasing in firm-level union density until around 70 percent of the workforce is organized, when the premium tops out at approximately 20 percent. There is also the suggestion that, with the growth in union density, comes an increasing substitution in favour of fringes from working-time related compensation in supplementing the bargain wage, which development is likely to be attractive to both employers and unions on tax-related grounds.

The main result of the decomposition exercise for actual/total earnings is that the union wage gap is mainly manifested through a firm fixed effect, implying that unions may force firms to reposition themselves as far as their wage compensation policies are concerned, although in this endeavor unions may be pushing on an open door. There is also some evidence of a job-title effect or 'occupation premium' generated in the formation of wage tables. Such job-title effects are stronger than worker unobserved quality; specifically, the heterogeneity in worker unobserved quality does not have significant effects.

Analysis of the bargained wage and the wage cushion cast further light on the union premium. In the first place, the bargained wage exhibits a peak union premium almost double that for total earnings. This outcome is the result of the definition of wage tables under collective bargaining that set the minima that firms can pay in the form of a base wage to a specific worker given that worker's job description at the firm *and* the firm's positioning of workers in these wage tables in applying a job description to a particular worker.

The association between union density and the wage cushion is in fact negative, and is increasing in absolute magnitude with union density. By virtue of its size, this does not mean that the wage premium secured through the bargained wage is largely undone, even if the premium for fringe benefits may in some circumstances be negative. That said, firms do offset to some degree the increase in bargained wages by reducing the average fringe benefits of the contract, as has been noted in the wider Portuguese research literature. Nevertheless, once we account for firm and worker heterogeneity, more unionized firms are again shown to have more generous compensation policies even in these flexible areas. This was made clear in our decomposition of the bargained wage and the wage cushion.

In a final exercise, we sought to establish whether our results might be contaminated by mis-measurement of the components of the average wage gap by neglecting job match considerations attendant

upon assortative matching, where high productivity workers align themselves with high productivity firms. In combining worker and firm fixed effects to allow for their interaction, our decomposition analysis showed that the joint effect differed imperceptibly from the sum of their separate individual effects in the standard estimation, indicating that the match component can safely be ignored.

The answers to the questions raised at the beginning of this exercise can now be adumbrated. First, traditional estimates of the union wage gap assuming linearity are flawed: the impact of union density is highly nonlinear. Second, there is evidence of a union preference for wage supplements as bargaining power increases. Third, the observed union wage gap would be very small were unionized workers randomly assigned to firms because the union wage gap is mainly manifested through a firm fixed effect. Fourth, once we consider total earnings, that part of the union premium associated with higher-paying job titles, via wage tables and average fringe benefits, is modest. Fifth, the evidence on worker fixed effects suggests that union workers are not more productive than their nonunion counterparts. Sixth, both bargained wages and the wage cushion play an important role in union wage determination since the premium would be much higher were workers solely remunerated according to the bargained wage. Seventh, some (less unionized) employers can partly undo at the firm level the bargained wages agreed to at industry level. But the role played by the wage cushion is hampered whenever unions are able to set high bargained wages. Finally, there is no indication that other than a trivial part of the union premium stems from assortative matching.

The bottom line of this exercise is that we have (a) used a novel procedure to establish the union premium in a regime where almost all workers are covered by a collective agreement (through extension) but few are unionized, (b) provided a unique attribution of that differential to three types of heterogeneity that left almost no room for alternative explanations of wage variation, and (c) offered an internally consistent set of results for bargained pay, total earnings, and the wage gap at the same time as finding support for the emerging consensus in the wider wage determination literature as to the importance of firm effects.

References

Addison, John T., Pedro Portugal, and Hugo Vilares. 2016. "Unions and Collective Bargaining in the Wake of the Great Recession: Evidence from Portugal." *British Journal of Industrial Relations* (forthcoming). Version of Record online: 30 AUG 2016 | DOI: 10.1111/bjir.12202.

Blanchflower, David, and Alex Bryson (2003). "Changes Over Time in Union Relative Wage Effects in the U.K. and the U.S.A. Revisited." In John T. Addison and Claus Schnabel (eds.), *International Handbook of Trade Unions*, pp. 197-245. Cheltenham, U.K. and Northampton, MA: Edward Elgar.

Blanchflower, David, and Alex Bryson. 2007. "What Effect Do Unions Have on Wages Now and Would Freeman and Medoff Be Surprised? In James T. Bennett and Bruce E. Kaufman (eds.), *What Do Unions Do? A Twenty-Year Perspective*, pp. 79-113. New Brunswick, NJ: Transaction Publishers.

- Buchmueller, Thomas C., John Dinardo and Robert G. Valletta. 2002. "Union Effects on Health Insurance Provision and Coverage in the United States." *Industrial and Labor Relations Review* 55(4): 610-627.
- Card, David. 1996. "The Effect of Unions on the Structure of Wages: A Longitudinal Analysis." *Econometrica* 64(4): 957-99.
- Cardoso, Ana Rute, and Pedro Portugal. 2005. "Contractual Wages and the Wage Cushion under Different Bargaining Settings." *Journal of Labor Economics* 23(4): 875-902.
- Cameron, Colin A., and Pravin K. Trivedi. 2005. *Microeconometrics. Methods and Applications*. Cambridge: Cambridge University Press.
- Carneiro, Anabela, Paulo Guimarães, and Pedro Portugal. 2012. "Real Wages, and the Business Cycle: Accounting for Worker, Firm, and Job Heterogeneity." *American Economic Journal: Macroeconomics* 4(2): 133-152.
- Efron, Bradley. 1979. "Bootstrap Methods: Another Look at the Jackknife." *The Annals of Statistics* 7(1): 1-26
- Farber, Henry S. 1986. "The Analysis of Union Behavior." In Orley Ashenfelter and Richard Layard (eds.), *Handbook of Labor Economics, Volume 1*, pp. 1039-1089. Amsterdam: North-Holland.
- Frandsen, Brigham R. 2102. "Why Unions Still Matter: The Effects of Unionization on the Distribution of Employee Earnings." Unpublished Paper, Massachusetts Institute of Technology. Available at: http://www.ewi-ssl.pitt.edu/econ/files/seminars/120224_sem_Brigham%20Frandsen.pdf.
- Felix, R. Alison, and James R. Hines. 2009. "Corporate Taxes and Union Wages in the United States." NBER Working Paper No. 15263. Cambridge, MA: The National Bureau of Economic Research.
- Figueiredo, Octávio, Paulo Guimarães, and Douglas Woodward. 2014. "Firm-Worker Matching in Industrial Clusters." *Journal of Economic Geography* 14(1): 1-19.
- Freeman, Richard B. 1981. "The Effect of Unionism on Fringe Benefits." *Industrial and Labor Relations Review* 34(4): 489-509.
- Gelbach, Jonah B. 2016. "When Do Covariates Matter? And Which Ones, and How Much?" *Journal of Labor Economics* 34(2): 509-543.
- Guimarães, Paulo, and Pedro Portugal. 2010. "A Simple Feasible Procedure to Fit Models with High-Dimensional Fixed Effects." *Stata Journal* 10(4): 628-649.
- Hirsch, Barry T. 2004. "Reconsidering Union Wage Effects: Surveying New Evidence on an Old Topic." *Journal of Labor Research* 25(2): 233-266.
- Hirsch, Barry T., and John T. Addison. 1986. *The Economic Analysis of Unions. New Approaches and Evidence*. Boston, MA: Allen & Unwin.
- Jung, Sven, and Claus Schnabel. 2011. "Paying More than Necessary? The Wage Cushion in Germany." *Labour* 25(2): 182-197.
- Lee, David S., and Alexandre Mas. 2012. "Long-Run Impacts of Unions on Firms: New Evidence from Financial Markets." *Quarterly Journal of Economics* 127(1): 333-378.

Martins, Pedro S. 2014. "30,000 Minimum Wages: The Economic Effects of Collective Bargaining Extensions." IZA Discussion Paper No. 8540. Bonn: Institute for the Study of Labor.

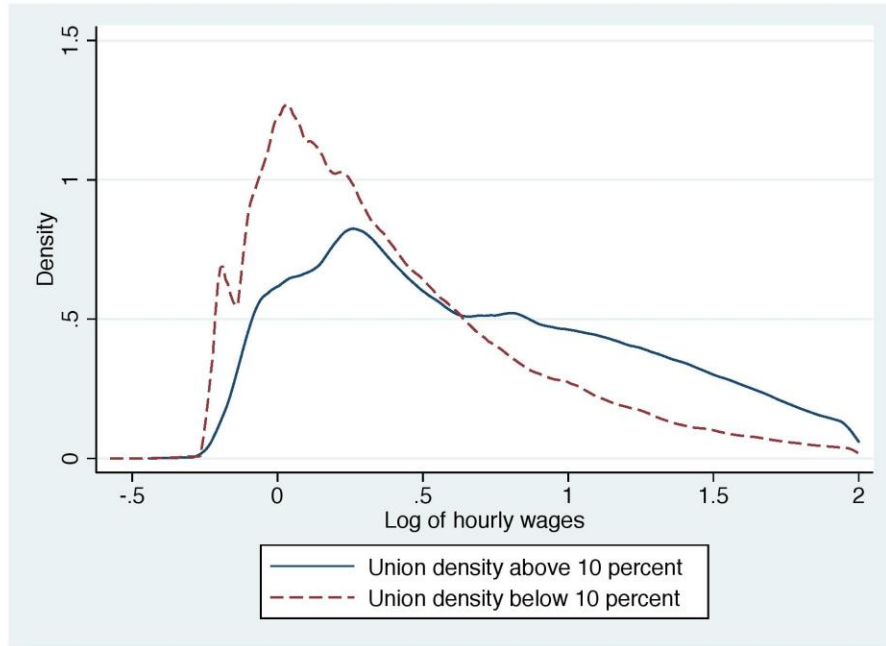
Palma Ramalho, Maria do Rosário. 2013. "Portuguese Labor Law and Industrial Relations during the Crisis." Working Paper No. 54. Geneva: International Labor Office.

Raposo, Pedro S., Pedro Portugal, and Anabela Carneiro. 2015. "Wage Losses of Displaced Workers: the Reallocation of Workers into Firms and Job Titles." IZA Discussion Paper No. 9220. Bonn: Institute for the Study of Labor.

Rees, Albert. 1960. *New Measures of Wage-Earner Compensation in the United States, 1914-1957*. New York: 1st Edition Books.

Torres, Sónia, Pedro Portugal, John T. Addison, and Paulo Guimarães. 2015. "The Sources of Wage Variation: A Three-Way High-Dimensional Fixed Effects Regression Model." Unpublished Paper, University of South Carolina.

Figure 1: Distribution of Total Monthly Wages by Union Status



Source: Relatório Único, 2010-2013.

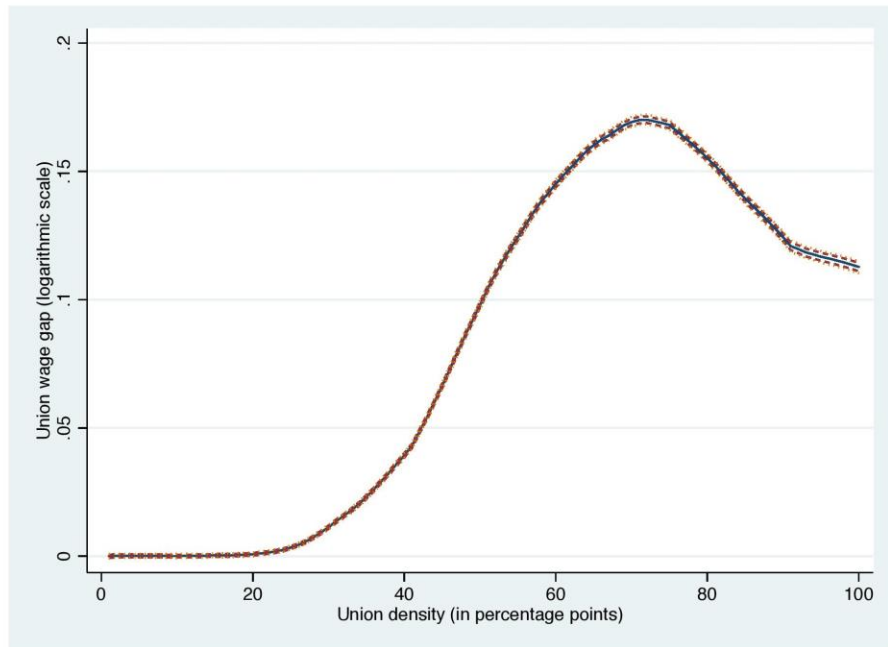
Table 1: OLS Estimation of the Union Wage Gap for Total Monthly Wages

Variables	Coefficient (s.e.)
Union density	0.1436*** (0.0128)
Worker's age	0.0287*** (0.0003)
Worker's age squared	-0.0002*** (3.92e-06)
Tenure of the Worker	-0.0002*** (0.0002)
Tenure of the Worker squared	-1.41e-06*** (5.34e-08)
Female	-0.2108*** (0.0018)
Primary school	0.0521*** (0.0035)
Basic school	0.1590*** (0.0037)
Elementary school	0.2898*** (0.0040)
Secondary school	0.4312*** (0.0050)
Post-secondary school	0.5575*** (0.0072)
University attendance	0.8203*** (0.0064)
Undergraduate degree	0.9089*** (0.0058)
Masters degree	0.9492*** (0.0061)
PhD degree	1.0514*** (0.0176)
Firms with 50 to 99 employees	0.1378*** (0.0024)
Firms with 100 to 499 employees	0.1784*** (0.0035)
Firms with 500 to 999 employees	0.2044*** (0.0104)
Firms with 1000 to 4999 employees	0.1557*** (0.0106)
Firms with more than 5000	0.1079*** (0.0200)
Sector of activity dummies (25)	Yes
Year dummies (26)	Yes
Constant	4.6033*** (0.0355)
Observations	6,814,269
R-squared	0.4836

Notes: Robust clustered firm-year standard errors are in parentheses: ***, **, * denote statistical significance at the 0.01, 0.05, and 0.10 levels, respectively.

Source: *Relatório Único, 2010-2013.*

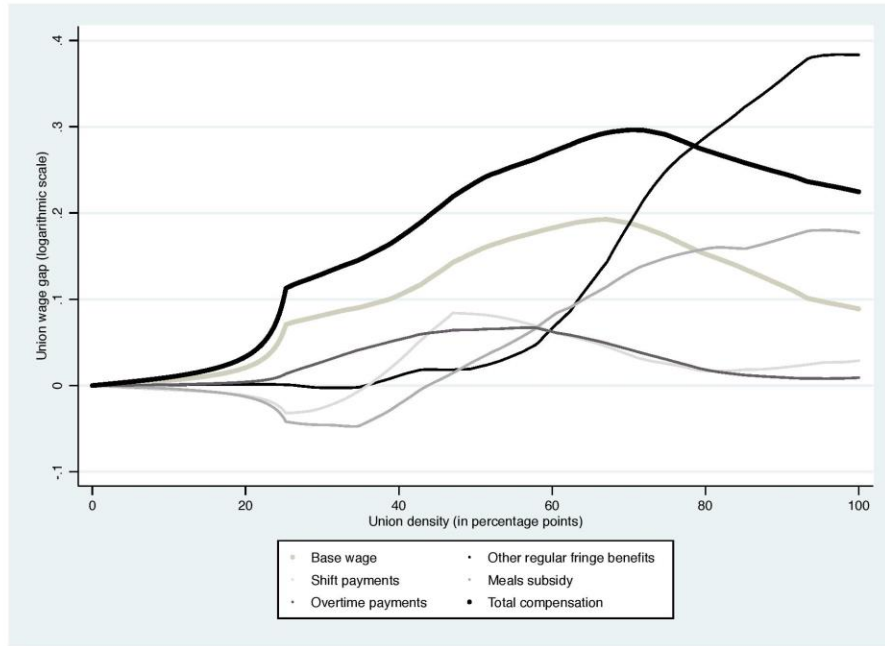
Figure 2: The Union Wage Gap Curve for Total Monthly Wages



Notes: The solid line corresponds to the point estimate. The 95 (90) percent Bootstrap confidence interval is given by the dashed (dotted) curves. The base model includes as regressors a quadratic term in age, a quadratic term in tenure, schooling dummies (10), a gender dummy, firm size dummies (5), and sector dummies (25). The number of observations is 6,814,269. The R^2 of the base model is 0.536.

Source: *Relatório Único, 2010-2013*.

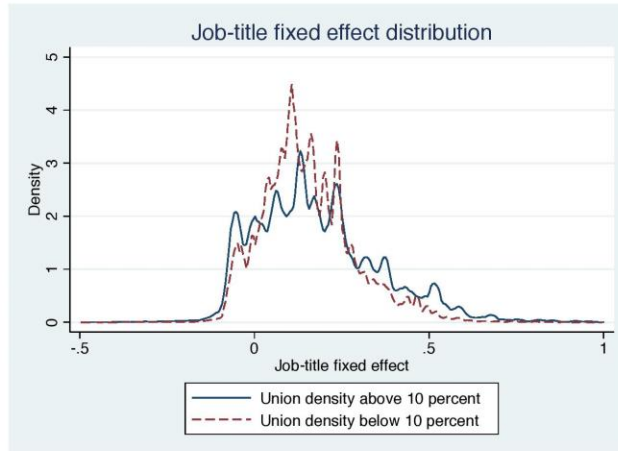
Figure 3: The Union Wage Gap Curve, by Component of Total Compensation



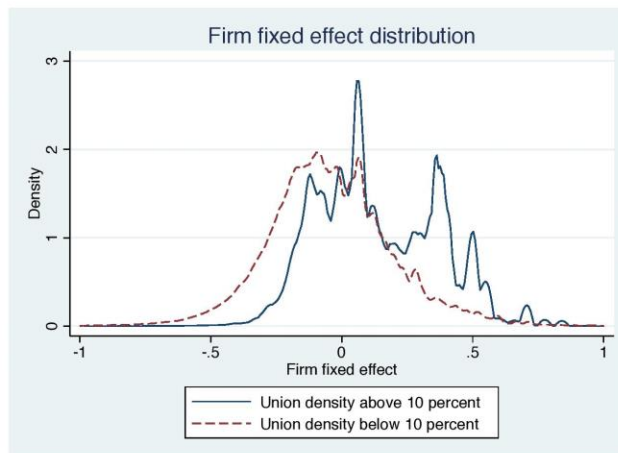
Notes: The union wage gap *curve* for total compensation differs slightly from that presented earlier in Figure 3, because the present figure contains information only from the 2010 wave of Relatório Único whereas Figure 3 uses information from the 2010-2013 waves.
Source: Relatório Único, 2010.

Figure 4: Distribution of Worker, Firm, and Job-Title Fixed Effects by Union Status

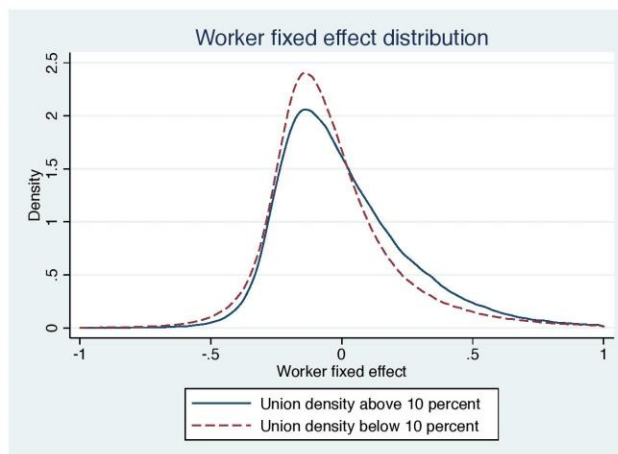
Panel A



Panel B



Panel C



Notes: In addition to the fixed effects, the model includes as regressors a quadratic term in age, a quadratic term in tenure, schooling dummies (10), a gender dummy, firm size dummies (5), and sector dummies (25). The number of observations is 39,442,324. The R^2 of the base model is 0.878.
Sources: *Quadros de Pessoal 1986-2009; Relatório Único, 2010-2013.*

Table 2: The Conditional Decomposition of the OLS Estimation of the Union Wage Gap for Total Compensation

Variables	Base Model Estimate	Full Model Estimate	Gelbach Decomposition
ψ_u (Estimated Union Wage Gap)	0.1436*** (0.0128)	-0.0022 (0.0049)	—
α_i (Worker FE)	—	—	-0.0042 (0.0039)
θ_j (Job-title FE)	—	—	0.0162*** (0.0055)
λ_f (Firm FE)	—	—	0.1340*** (0.0073)

Notes: Decomposition based on Gelbach (2016). Robust clustered firm-year standard errors are in parentheses: ***, **, * denote statistical significance at the 0.01, 0.05, and 0.10 levels, respectively. The base model includes as regressors a quadratic term in age, a quadratic term in tenure, schooling dummies (10), a gender dummy, firm size dummies (5), and sector dummies (25). The number of observations is 39,442,324. The R^2 of the base and full models are, respectively, 0.4836 and 0.878. *Sources:* *Quadros de Pessoal 1986-2009; Relatório Único, 2010-2013.*

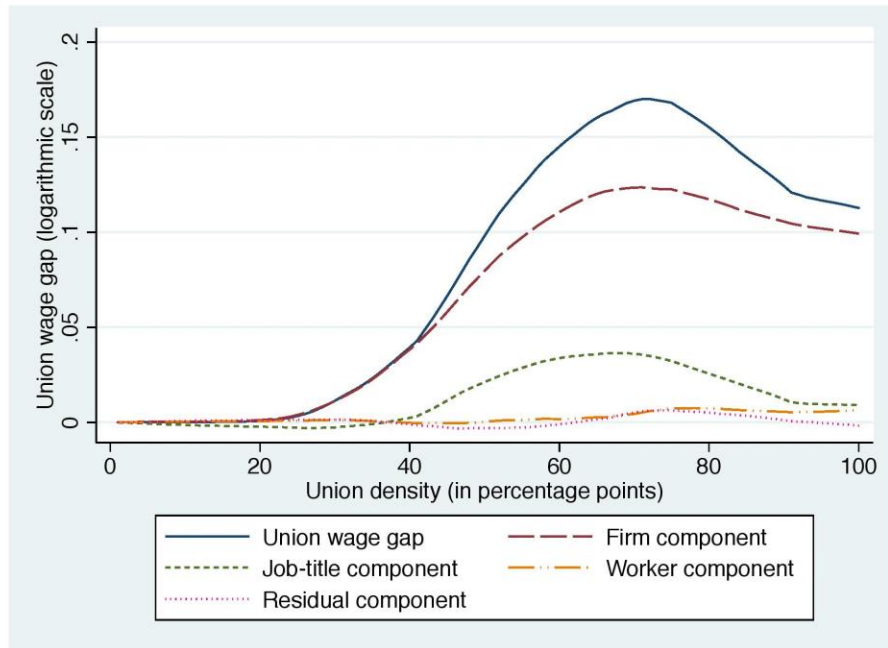
Table 3: The Conditional Decomposition of the OLS Estimation of the Union Wage Gap for Different Model Specifications

Variables	Base Model Estimate	Full Model Estimate	Gelbach Decomposition
Standard Model			
ψ_u (Estimated Union Wage Gap)	0.1436*** (0.0128)	-0.0022 (0.0049)	-
α_i (Worker FE)	-	-	-0.0042 (0.0039)
θ_j (Job-title FE)	-	-	0.0162*** (0.0055)
λ_f (Firm FE)	-	-	0.1340*** (0.0073)
Standard Model without Firm Size and Sector Dummies.			
ψ_u (Estimated Union Wage Gap)	0.4216*** (0.0159)	-0.0201*** (0.0052)	-
α_i (Worker FE)	-	-	0.0071 (0.0044)
θ_j (Job-title FE)	-	-	0.0096 (0.0070)
λ_f (Firm FE)	-	-	0.4251*** (0.0094)
Standard Model without Education, Firm Size and Sector Dummies.			
ψ_u (Estimated Union Wage Gap)	0.6351*** (0.0270)	-0.0149*** (0.0053)	-
α_i (Worker FE)	-	-	0.1007*** (0.0093)
θ_j (Job-title FE)	-	-	0.0733*** (0.0090)
λ_f (Firm FE)	-	-	0.4760*** (0.0118)

Notes: Decomposition based on Gelbach (2016). Robust clustered firm-year standard errors are in parentheses: ***, **, * denote statistical significance at the 0.01, 0.05, and 0.10 levels, respectively. The standard model includes as regressors a quadratic term in age, a quadratic term in tenure, schooling dummies (10), a gender dummy, firm size dummies (5), and sector dummies (25). The number of observations is 39,442,324. In the standard model, the R^2 terms of the base and full models are 0.4836 and 0.878, respectively. In the standard model without firm size and sector dummies, the R^2 terms are 0.4331 and 0.877; and for the standard model without education, firm size and sector dummies the R^2 terms are 0.1791 and 0.877.

Sources: Quadros de Pessoal 1986-2009; Relatório Único, 2010-2013.

Figure 5: The Gelbach Decomposition of the Union Wage Gap Curve for Total Compensation



Sources: Quadros de Pessoal 1986-2009; Relatório Único, 2010-2013.

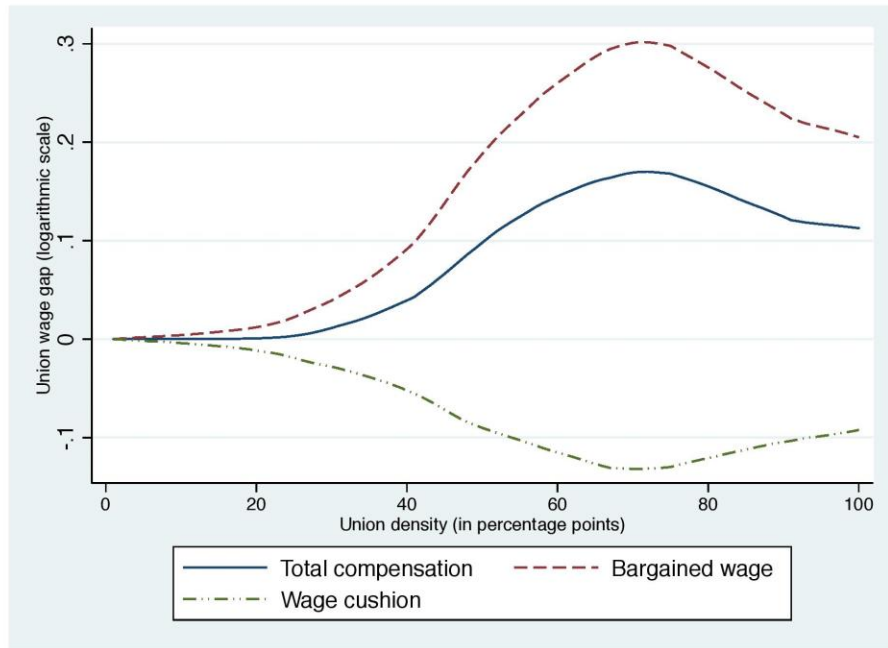
Table 4: The Conditional Decomposition of the OLS Estimation of the Union Wage Gap for Total Compensation, the Bargained Wage, and the Wage Cushion

Variables	Base Model Estimate	Full Model Estimate	Gelbach Decomposition
Total Compensation			
ψ_u (Estimated Union Wage Gap)	0.1436*** (0.0128)	-0.0022 (0.0049)	-
α_i (Worker FE)	-	-	-0.0042 (0.0039)
θ_j (Job-title FE)	-	-	0.0162*** (0.0055)
λ_f (Firm FE)	-	-	0.1340*** (0.0073)
Bargained Wage			
ψ_u (Estimated Union Wage Gap)	0.2860*** (0.0187)	-0.0288*** (0.0050)	-
α_i (Worker FE)	-	-	-0.0086** (0.0036)
θ_j (Job-title FE)	-	-	0.1691*** (0.0147)
λ_f (Firm FE)	-	-	0.1546*** (0.0123)
Wage Cushion			
ψ_u (Estimated Union Wage Gap)	-0.1417*** (0.0140)	0.0260*** (0.0058)	-
α_i (Worker FE)	-	-	0.0016 (0.0005)
θ_j (Job-title FE)	-	-	-0.1703*** (0.0144)
λ_f (Firm FE)	-	-	7.69e - 06 (0.0109)

Notes: Decomposition based on Gelbach (2016). Robust clustered firm-year standard errors are in parentheses: ***, **, * denote statistical significance at the 0.01, 0.05, and 0.10 levels, respectively. The base model includes as regressors a quadratic term in age, a quadratic term in tenure, schooling dummies (10), a gender dummy, firm size dummies (5), and sector dummies (25). The number of observations is 39,442,324. The R^2 terms of the base and full models for total compensation are 0.4836 and 0.878, respectively. For bargained wage they are 0.3869 and 0.882; and for the wage cushion they are 0.1344 and 0.6883.

Sources: *Quadros de Pessoal 1986-2009; Relatório Único, 2010-2013.*

Figure 6: The Union Wage Gap Curve for Total Compensation, the Bargained Wage, and the Wage Cushion



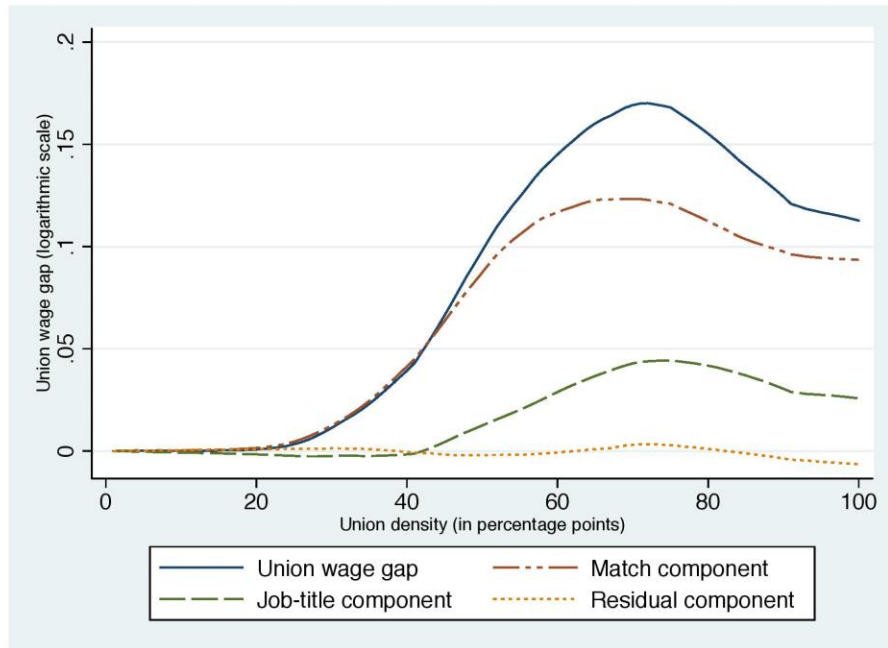
Source: Relatório Único, 2010-2013.

Table 5: The Conditional Decomposition of the OLS Estimation of the Union Wage Gap for Total Compensation, Introducing a Job Match Component

Variables	Base Model Estimate	Full Model Estimate	Gelbach Decomposition
ψ_u (Estimated Union Wage Gap)	0.1436*** (0.0129)	-0.0049 (0.0045)	—
μ_{if} (Match FE)	—	—	0.1272*** (0.01)
θ_j (Job-title FE)	—	—	0.0219*** (0.0047)

Notes: Decomposition based on Gelbach (2016). Robust clustered firm-year standard errors are in parentheses: *** denote statistical significance at the 0.01 level. The base model includes as regressors a quadratic term in age, a quadratic term in tenure, schooling dummies (10), a gender dummy, firm size dummies (5), and sector dummies (25). The number of observations is 39,442,324. The R^2 of the base and full models are, respectively, 0.4829 and 0.9134.
Sources: Quadros de Pessoal 1986-2009; Relatório Único, 2010-2013.

Figure 7: The Gelbach Decomposition of the Union Wage Gap Curve for Total Compensation, Introducing a Job Match Component



Sources: Quadros de Pessoal 1986-2009; Relatório Único, 2010-2013.