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Estimating the employer size-wage premium in a panel data model with comparative advantage and non-random selection

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Abstract

This paper considers the estimation of the employer-size wage effect using a panel of employer-employee matched data. We test for the possibility of different returns to observable human capital variables as well as examine the role played by unmeasured skills in driving the allocation of workers across firms of different sizes. Our results show that some of the observed skills; namely, education, age, and tenure have high returns in large firms, while the opposite is true for high skilled occupations and for the gender gap. On the other hand, the price of non-observed skills is reduced as firm size increases. This finding is consistent with explanations based on the premise that large employers have more difficulty monitoring workers, which therefore leads them to monitor less closely.

JEL: *D20, J21,J24, J31*

Keywords: *firm size, wages, non-random selection.*

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1 Introduction

The fact that large employers pay higher wages than small employers has long been recognized as an important component of the variation in workers' wages[1]. In the U.S. economy, this wage gap is approximately equal to the gender wage gap and larger than the one associated with unionism or race. However, previous attempts to account for this premium using observable worker or employer characteristics have had limited success, and there remains a significant and unexplained premium paid to workers of large employers[2].

The literature to date, surveyed first by Brown and Medoff (1989) and more recently by Oi and Idson (1999), has mainly considered this wage gap as a difference in wage levels, which means that the effect of firm size on workers' earnings is independent of their skills. Differences in the prices of workers' skills have also been considered, but only in terms of measured skills (e.g. Troske, 1999). However, unmeasured skills, such as "ability", may play an important role in sorting workers into firms of different size, particularly if individual ability is not equally valued in small and large firms.

Several explanations support the idea that the effect of firm size on workers' earnings is independent of their skills. Some of these are related with

[1] This relation was first discovered by Henry L. Moore (1911).

[2] See, for the US case, the seminal work of Brown and Medoff (1989). For Europe, see the work of Winter-Ebmer; Zweimuller (1999) for Switzerland; or Albaek, Arai, Asplund, Barth and Madsen (1998) for Nordic countries.

the behavior of the entrepreneurs that control large organizations. Models based on the efficiency wage theory[3] and on the rent-sharing hypothesis[4] can be included in this set of behavioral explanations. Also, if working conditions in small firms are better than in large firms, lower job satisfaction can be a reason for workers in large firms to ask for a wage premium in order to comply with these working conditions[5]. The second set of explanations for the size-wage premium, in levels, is related with the idea that wages and overall productivity move together, namely if there are increasing returns to establishment and firm size due to technical economies as well as agglomeration effects. These are related to the higher capital/labor ratios and to the quality of the capital employed in larger plants that raise labor productivity for all workers.

Differences in the prices of workers' skills can also be justified in several ways. Workers' skills can be more productive in large firms than in small firms due to the complementarity between physical capital and human capital. Then, large firms prefer a more skilled labor force, and they are more able to pay higher prices for these skills. On the other hand, measured skills (like education or experience) and unmeasured skills may be priced differently by large and small firms due to differences in monitoring costs (Garen, 1985). If these monitoring costs are higher in large firms, then these type

[3] Bulow and Summers (1986) show that large employers will choose to pay higher wages in order to reduce the amount of monitoring.

[4] See, for example Weiss (1966) or Akerlof and Yellen (1990).

[5] Brown and Medoff (1990) found little evidence of this.

of firms may prefer to reward better the skills that are directly observable relative to small firms. Therefore, different returns to both measured and unmeasured components of human capital can be expected, but it is not clear, a priori, what is the overall effect on wage profiles.

Empirical methodology used in these studies consists in estimating a mincerian wage equation, where variables on firm and/or establishment size are included. However, measures of the skills available in standard data sets are imperfect because some workers' skills are observed by the market but not by the econometrician. This problem has been partially reduced in panel data models, in which unobserved skills are partially captured by a time-invariant fixed effect that is equally valued by firms, independent of their size, but a more realistic model might have to assume that not only do workers' characteristics vary by firm size, but also the returns to these characteristics. If worker's skills are not identically productive across the firms' size spectrum, we can expect that workers sort themselves between large and small firms according to their skills' endowments and returns.

The selection bias generated by the non-random allocation of workers with different skills into employers of different sizes has been adjusted by the estimation of selectivity-corrected models that include a prediction of the size category in which the worker will be employed (Idson and Feaster, 1990; Lluis, 2003). The results show evidence of non-random selection of workers into firms of different sizes. This selection is found to be negative in large firms and positive in small firms, and they conclude that workers in large firms are of lower quality in terms of unmeasured skills. However, as pointed out by Oi and Idson (1999), this kind of correction implicitly assumes that the "value" of the unobserved drive and motivation is the same across firm sizes. Attributes such as individual initiative that are productive in small firms may actually be a hindrance in large firms that organize production around structured teams. Also, in this framework, the selection rule only comes from one side of the market.

The major contribution of our paper is the extension of the available empirical literature, not only methodologically, but also in terms of the use of a very rich database. First, we estimate the size-wage gap using an estimator that extends the standard panel data techniques to the case in which the return to permanent component of the error term is differently rewarded across firm sizes. This is a case of a more general model with interactions between time-varying explanatory variables and some unobservable, time-constant variables. It can be shown that a model of this type can be estimated using a non-linear instrumental-variables technique. This strategy has been used in other contexts in which first-differenced estimates are inconsistent, specially in the case of the additive unobserved effect not having the same effect in all time periods as in Holtz-Eakin, Newey and Rosen (1988), or as in Lemieux (1998), who estimates a model in which the return to time-invariant unobserved characteristic is different in the union and the non-union sectors. More recently Gibbons, Katz, Lemieux and Parent (2002) apply a similar methodology to study the wages and allocation of workers across occupations and across industries.

Second, previous empirical work has relied on either worker surveys with little information about the employer or establishment surveys with little information about the workers. In contrast, this study uses employer-employee matched data, and therefore not only can some aspects of the labor demand side be controlled, but we can also exploit the panel structure of the data to account for the individual unobserved heterogeneity. Also we will focus our econometric estimations on a sample of workers displaced by firms closings, as in Gibbons and Katz (1992), which reduces the problems generated by endogenous worker-firm mobility.

Our results are consistent with previous findings on the subject, although we are using a different sample in a different national context. Some of the observed skills, namely education, age and tenure have high returns in large firms, while the opposite is true for high skilled occupations and for the gender gap. On the other hand, the price of non-observed skills is reduced as firm size increases. This finding is consistent with explanations based on the premise that large employers have more difficulty monitoring workers, and therefore leads them to monitor less closely.

The paper is structured as follows. Section 2 presents the basic model of wage determination and firm size-type choice, and the estimation strategy.

The data from the 1994-1998 Portuguese "Quadros de Pessoal" dataset is presented in Section 3. Section 4 shows the results of the estimations, and, finally, Section 5 concludes the paper.

2 Model and Econometric Framework

2.1 The Model

This section presents an estimable two-sector model of wage determination and firm choice, in which technologies are differently sensitive to workers' observed and unobserved skills. Therefore, workers are not identically productive in large and small firms, and non-random assignment of workers into firms of different size arises.

The model consists in a set of identical firms that differ only in their size j, small (S) or large (L) ($j \epsilon \{S, L\}$), operating in a competitive environment and producing output using labour as the only input. Worker i has effective ability θ_i, not observed by the econometrician, and other measured human capital endowments $\mathbf{X}'_{it}$. The production technology is such that if worker i is assigned to firm with size j, in time t ($t = 1, 2, ..., T$), he produces y^j_{it}

$$y^j_{it} = \exp(\alpha^j_0 + \mathbf{X}'_{it}\beta^j + c^j\theta_i + \varepsilon_{it}), j = S, L \tag{1}$$

where ε_{it} captures all productivity shocks, uncorrelated with $\mathbf{X}'_{it}$ and θ_i. Due to competition among firms, the wage is equal to the output. Therefore the (log) wage is:

$$\ln w_{it}^{j} = \alpha_0^{j} + \mathbf{X}_{it}'\beta^{j} + c^{j}\theta_i + \varepsilon_{it} \tag{2}$$

Note that $\mathbf{X}_{it}'$ and θ_i can be priced differently across firms of different sizes, because $\beta^j \in \{\beta^S, \beta^L\}$ and $c^j \in \{c^S, c^L\}$. The difference $\alpha_0^L - \alpha_0^S = \overline{\alpha}_0$, is "pure" firm size-wage premium, independent of the worker's characteristics that measure "true size-wage effects", such as rent-sharing or overall firm productivity, and c^j measures the sensitivity of the price of effective ability to the firm size. The constants α^j, β^j, and c^j are known to all labor-market participants.

Assume that:

$$\alpha_0^L = \alpha_0^S + \overline{\alpha}_0, \tag{3}$$

$$c^S = 1 \tag{4}$$

and

$$c^L = (1 + \psi). \tag{5}$$

Hence, the wage of a worker in a large firm is given by:

$$\ln w_{it}^L = \alpha_0^S + \overline{\alpha}_0 + \mathbf{X}_{it}'\beta^L + (1 + \psi)\theta_i + \varepsilon_{it}, \tag{6}$$

and the correspondent wage in a small firm is:

$$\ln w_{it}^S = \alpha_0^S + \mathbf{X}_{it}'\beta^S + \theta_i + \varepsilon_{it}. \tag{7}$$

It is easy to see that, for each worker, the expected wage difference between large firms and small firms is:

$$E(D_{it}) = \overline{\alpha}_0 + \mathbf{X}_{it}'(\beta^L - \beta^S) + \psi\theta_i. \tag{8}$$

In this framework, the wage difference between large and small firms has three different sources: the first is the "pure" firm size-wage premium which leads to different intercepts in the earnings equation. The second source of the gap is related to differences in measured skills' prices, and finally, the remaining part of the gap is due to differences in returns to unobservable skills.

Workers are utility maximizers and the utility associated with working in a large or small firm is a function of firm attributes that are size specific, such as wage or working conditions. Also, we will consider a parameter to capture the disutility related with inter-firm mobility, not related with the wage. Workers prefer to work in large firms as long as the utility acquired in this type of firm is greater than the utility of working in a small firm, excluding the mobility (utility) costs.

Let V_{it}^{j} denote the indirect utility of working in a firm of size j, at time t, which is given by:

$$\ln V_{it}^{j} = \delta_{0t}^{j} - \delta_{1,(t,t-1)}^{i} + \delta_2 \ln w_{it}^{j}, j = S, L, \tag{9}$$

where δ_{0t}^{j} is a parameter that measures the effect of working conditions on the worker's utility, and $\delta_{1,(t,t-1)}^{i}$ is a measure of the mobility (utility) costs[6]. This parameter is set to zero if the worker stays in the same firm in both periods $t-1$ and t, and has some positive value if the worker leaves one firm at $t-1$ to join another at t.

A worker prefers to work at a large firm if his utility V_{it}^{L} is greater than

[6] This parameter will be important to rationalize worker's mobility, uncorrelated with his wage setting.

the utility of working in small firm V_{it}^{S}. Representing the (expected) net gain of choosing a large firm by the latent variable $U_{it}^{*} = E(V_{it}^{L} - V_{it}^{S})$, the assignment rule of a worker into a large or small firm corresponds to the following conditions:

$$\text{the worker } i \text{ chooses } L :\rightarrow U_{it}^{*} > 0 \rightarrow (\delta_{0t}^{L} - \delta_{0t}^{S}) - \delta_{1,(t,t-1)}^{i} + \delta_{2}E(D_{it}) > 0 \tag{10}$$

and

$$\text{the worker } i \text{ chooses } S :\rightarrow U_{it}^{*} < 0 \rightarrow (\delta_{0t}^{L} - \delta_{0t}^{S}) - \delta_{1,(t,t-1)}^{i} + \delta_{2}E(D_{it}) < 0. \tag{11}$$

Finally, the allocation rule is: a worker with endowment $(\mathbf{X}'_{it}, \theta_i)$ and mobility costs $\delta_{1,(t,t-1)}^{i}$ chooses a large firm if and only if:

$$U_{it}^{*} > 0 \rightarrow \frac{1}{\delta_2}[(\delta_{0t}^{L} - \delta_{0t}^{S}) - \delta_{1,(t,t-1)}^{i}] + [\overline{\alpha}_0 + \mathbf{X}'_{it}(\beta^{L} - \beta^{S})] > -\psi\theta_i. \tag{12}$$

This assignment rule states workers' preferences according to their skills endowments and returns, working conditions and inter-firm mobility costs. Individuals' movements between large and small firms can be rationalized by changes in $\mathbf{X}'_{it}$, δ_{0t}^{j} or $\delta_{1,(t,t-1)}^{i}$. However, $\mathbf{X}'_{it}$, is composed by some time invariant characteristics, such as gender or education, and therefore changes in $\mathbf{X}'_{it}$ are only due to job tenure or labor market experience. Also, large changes in the difference $(\delta^L_{0t} - \delta^S_{0t})$ cannot be expected. Nevertheless, considering mobility costs may be a way to explain worker's mobility. Suppose that a certain number of workers lose their jobs because of (exogenous) firm closures. All of these workers have to support some mobility costs $\delta^i_{1,(t,t-1)}$, in order to be hired by another firm. Therefore, for these workers, the utility thresholds that assign them to a large or small firm will be less restrictive, and we can expect more mobility from large to small firms and vice-versa.

2.2 Econometric Specification

An estimable wage equation is obtained by concentrating the small and the large firm's wages into the following equation:

$$\ln w_{it} = L_{it}(\ln w^L_{it}) + (1 - L_{it})(\ln w^S_{it}) + \varepsilon_{it} \tag{13}$$

where L_{it} is a dummy variable that equals to one when the worker is in a large firm and zero otherwise[7]. ε_{it} is an idiosyncratic error term that captures all the determinants of the individual wage, not correlated with worker's skills and firm size. Plug-in the equations (6) and (7), we have:

[7] The variable L_{it} can also be continuous, as the log of firm's employment. We keep this variable as a dummy just for simplicity. In the empirical estimation we will use the continuous measure of the firm size.

$$\ln w_{it} = \alpha_0^S + \mathbf{X}_{it}'\beta^S + \theta_i + L_{it}\left[\overline{\alpha}_0 + \mathbf{X}_{it}'(\beta^L - \beta^S) + \psi\theta_i\right] + \varepsilon_{it} = \tag{14}$$

$$= \alpha_0^S + L_{it}\overline{\alpha}_0 + \mathbf{X}_{it}'\left[\beta^S + L_{it}(\beta^L - \beta^S)\right] + \left[1 + L_{it}\psi\right]\theta_i + \varepsilon_{it}. \tag{15}$$

The last equation allows the time-constant unobserved heterogeneity θ_i to interact with the firm size variable L_{it}. This is an example of a more general model with interactions between time-varying explanatory variables and some fixed unobservables. Models of this type were studied by Polachek and Kim (1994), where the return to experience is allowed to be person specific, and Lemieux (1998) who estimates a model in which the return to the time-invariant unobserved characteristic is different in the union and the non-union sectors. More recently, Gibbons, Katz, Lemieux and Parent (2002), analyze the theoretical and econometric implications of models of this type to explain the wage differentials by industry and occupation[8].

Estimating the previous equation with OLS would give inconsistent estimates of the average wage gap $\overline{\alpha}_0$, because the error component $\left[1 + L_{it}\psi\right]\theta_i$ is correlated with L_{it}, if θ_i is a determinant of the worker's firm choice. Also, θ_i cannot be eliminated by first-differencing equation (15) because it is interacted with the $\left[1 + L_{it}\psi\right]$ term. Nevertheless, consistent estimates of the firm size wage premium can be obtained by quasi-differencing the equation

[8] See also Wooldridge (2002), ch. 11, for a survey.

of interest and using appropriate instrumental-variable techniques, as we will explained next.

2.3 Estimation Method

The first step is to solve equation (15) for θ_i :

$$\theta_i = \frac{\ln w_{it} - [\alpha_0^S + L_{it}\overline{\alpha}_0 + \mathbf{X}'_{it}\left[\beta^S + L_{it}(\beta^L - \beta^S)\right] + \varepsilon_{it}]}{[1 + L_{it}\psi]}. \qquad (16)$$

If we take the first lag of the above expression and substitute θ_i into (15), the final equation is given by:

$$\begin{aligned} \ln w_{it} &= \left[\alpha_0^S + L_{it}\overline{\alpha}_0 + \mathbf{X}'_{it}\left(\beta^S + L_{it}(\beta^L - \beta^S)\right)\right] + \frac{[1 + L_{it}\psi]}{[1 + L_{it-1}\psi]} \times \qquad (17) \\ &\times \left[\ln w_{it-1} - [\alpha_0^S + L_{it-1}\overline{\alpha}_0 + \mathbf{X}'_{it-1}\left(\beta^S + L_{it-1}(\beta^L - \beta^S)\right)]\right] + e_{it}, \end{aligned}$$

where

$$e_{it} = \varepsilon_{it} - \frac{[1 + L_{it}\psi]}{[1 + L_{it-1}\psi]}\varepsilon_{it-1}. \qquad (18)$$

The term $\left[\ln w_{it-1} - [\alpha_0^S + L_{it-1}\overline{\alpha}_0 + \mathbf{X}'_{it-1}\left(\beta^S + L_{it-1}(\beta^L - \beta^S)\right)]\right]$ is the excess wage that indicates how much the observed wages departs from the wage predicted on the basis of observed characteristics. Hence, the equation (17) indicates how the excess wage in period t is related to the excess wage in period $t-1$. This relationship is equal to $1+\psi$ for workers that move from a small firm to a large firm, and it is equal to one for stayers.

Equation (17) is non-linear and could be estimated by nonlinear least squares. However, $\ln w_{it-1}$ is correlated with ε_{it-1} and thus with e_{it} by construction. Therefore we have to use appropriate instruments that are correlated with $\ln w_{it-1}$ but not with e_{it}. The two period lagged information on firm and job characteristics can be used as instruments for $\ln w_{it-1}$ as long as some additional assumptions are made.

The most important assumption to estimate consistently (15) is the strict exogeneity assumption:

$$E(\varepsilon_{it}|L_{i1},...L_{iT},\mathbf{X}_{i1},...,\mathbf{X}_{iT},\theta_i)=0, \tag{19}$$

which says that, once observable characteristics $\mathbf{X}_{it}$, firm size L_{it} and unobservables θ_i have been controlled for, $(L_{is},\mathbf{X}_{is})$ for $s\neq t$, do not help to explain the $\ln w_{it}$. The use of two period lagged firm and job characteristics as instruments also implies the assumption that these variables only affect current (log) wage through variations in $\ln w_{it-1}$, which means that ε_{it} should be uncorrelated with its past values. This can be expected because we use a sample of displaced workers by firms closures: it is likely that firm characteristics at $t-2$ are correlated with worker's wage at $t-1$, but we can easily assume that these instruments only (conditionally) affect $\log w_t$ through $\log w_{t-1}$, because at t workers will be allocated to different firms.

Assumption (19) rules out the possibility that temporary sector or individual specific shocks can affect the firm size choice. Also, changes in the quality of job matches should not be correlated with changes in firm type affiliation. Only permanent comparative advantage can be correlated with the firm size choice, as predicted in the previous theoretical model.

However, we would not have this problem if we based our estimation on a group of workers that were exogenously removed from their jobs and then randomly assigned to new firms. Some workers were assigned to firms of the same size as before, while others were assigned to firms of different sizes. Unfortunately, we do not have data on such experiments, but we can select a group of workers that were displaced and who lost their jobs because of firm closings. Note that this sample is only random if the probability of being displaced by a firm closing is not correlated with the error term ε_{it}. Therefore, some control for firm attributes are necessary, which will be included in the vector X_{it}. In spite of this limitation, this sample is particularly helpful, not only because we get more variation on the variables of interest, namely the firm size indicator, but also because firm choice after displacement is more likely to be (conditionally) exogenous. The use of this particular sample, provides variation only through firm-movers, which rules out the endogeneity that arises from firm growth effects on worker's wages, through promotions or on-the-job training.

The estimation procedure, will be based in a GMM estimator, which can be estimated following the next steps. The assumption that the instruments $\mathbf{Z}_i$ are exogenous can be expressed as:

$$E(\mathbf{Z}_i' e_i) = 0. \tag{20}$$

The P instruments give us a set of P moments, $g_i(\widehat{\boldsymbol{\phi}}) = \mathbf{Z}_i'\widehat{e}_i = \mathbf{Z}_i'(\log w_t - f(\widehat{\boldsymbol{\phi}}))$, where $f(\widehat{\boldsymbol{\phi}})$ is the lhs of equation 17, without the error term, and $\widehat{\boldsymbol{\phi}}$ the vector of parameters α, β, ψ to be estimated.

The GMM estimator $\widehat{\boldsymbol{\phi}}_{GMM}$ for $\boldsymbol{\phi}$ is the one that minimizes the GMM objective function:

$$J(\widehat{\boldsymbol{\phi}}) = g(\widehat{\boldsymbol{\phi}})' W g(\widehat{\boldsymbol{\phi}}), \tag{21}$$

where $g(\widehat{\boldsymbol{\phi}}) = \frac{1}{n}\sum_{i=1}^{n} g_i(\widehat{\boldsymbol{\phi}}) = \frac{1}{n}\mathbf{Z}'\widehat{e}$.

The efficient GMM estimator is the GMM estimator with an optimal weighting matrix W, one which minimizes the asymptotic variance of the estimator. This is achieved by choosing $W = S^{-1}$, where S denotes the covariance matrix of the moment conditions g :

$$S = \frac{1}{n}E(Z'ee'Z) = \frac{1}{n}E(Z'\Omega Z). \tag{22}$$

To allow for heteroskedasticity, first the parameters contained in the vector $\boldsymbol{\phi}$ are estimated, using $S = \frac{1}{n}E(Z'Z)$, with $\Omega = I$. These consistent but inefficient parameters are used to compute a heteroskedasticity-robust variance matrix $\widehat{S}$:

$$\widehat{S} = \frac{1}{n}(Z'\widehat{ee}'Z) = \frac{1}{n}(Z'\widehat{\Omega}Z), \tag{23}$$

and efficient GMM estimates are obtained using $W = \widehat{S}^{-1}$. The overidentification test is computed as n times the value of the minimized function $J(\widehat{\boldsymbol{\phi}})$, which follows a χ^2 with degrees of freedom equal to the overidentificatying restrictions (the difference between the number of instruments and the number of parameters).

3 Data

3.1 Variables and Sample Selection

In this work we estimate regressions of logarithm of hourly wages on covariates representing gender, human capital (education, age, occupational status and tenure), firm attributes (size indicator, sales, average education, ownership status and region) and industry indicators. The data employed were obtained from an administrative source ("Quadros de Pessoal", hereafter QP), which has been employed for statistical purposes by the Ministry of Employment. This source covers all firms employing paid labor in Portugal and records detailed information on all individuals on the payroll in October (March, before 1993).The survey records information on salaries as well as on worker's attributes such as gender, education, age and tenure for over 2 and a half million people every year. Moreover, it also records information on the employer, from which we used firm size and sales, average education and ownership status (whether the firm is majority owned by private domestic, foreign or state), industry and location. The existence of a unique identification number (social security number) for the workers and firms enables the construction of a panel of workers matched with firm's characteristics.

Sample selection From the original dataset, we selected the observations on the following basis: first we dropped part-time workers as well as workers that did not work the normal period in the month of the survey (about 22% of whole dataset). Recall that the information on social security numbers is not validated because is not used for the production of official statistics and consequently there are some coding errors and missing observations. Therefore, we dropped all observations without a valid identification number (3 to 7%, depending on the year) and dropped all individuals whose identification number appears twice or more, after keeping the full-time workers. This is probably due to a typo or a mistake when the data was introduced, but also could be the case that some individuals have more than one full time job. Note that if some workers have a full-time job and a part-time one, then the information related with the latter job is deleted, while we maintained the former.

Then, we excluded all the observations for which one of the variables used in our analysis is missing, such as education level or date of birth and then we retained only the workers in firms with more than five employees, non-agriculture or fishery, and located in continental part of Portugal.

In order to reduce the endogeneity of movement decision we considered a sample of displaced workers, who lost their jobs because of firms closings in 1995, 1996 and 1997[9]. Also, we only kept workers with full information one year before displacement (moment $t-1$), three years before (moment $t-2$) and one year after displacement (moment t). So, our sample has three sets of workers: displaced in 1995 and observed in 1992, 1994 and 1996; displaced workers in 1996 and observed in 1993, 1995 and 1997; and, finally, displaced workers in 1997 and observed in 1994, 1996 and 1998. The total number of individuals in the full sample is 25151.

[9] We assumed that we observe a firm closing if the identification number of one firm appeared in period t but did not appear in $t+1, t+2$ and/or $t+3$.

The variables of Interest The Data Appendix A gives us detailed information about all the variables. The wage variable that we used was the log of hourly earnings, where earnings were defined as the sum of all regular wage components. Earnings and labor time were measured in the months of March (1992) and October (from 1993 to 1998). This variable is not deflated by the consumer price index because, in the estimation, all variables are centered around their means. This is required in order to estimate equation (17), because we cannot include a constant, due to multicollinearity of the regressors. Therefore, we implicitly assume that $E(\theta_i) = 0$.

The information about the education of the workers was given in levels (primary school, low secondary school, high school and college), so we converted it to the corresponding years of schooling to compute the average schooling at the firm level[10]. From the workers file we extracted the variables gender, age, occupation (managers and executives, high skilled, skilled and non-skilled) and tenure. From the firm files we used sector (we set 6 different sectors: manufacturing, construction, trade, transports and communications, finance and other services), equity capital share of foreign owners, sales and employment level as our firm size indicator. We also include a dummy for each region (we consider 5 different regions: the North, the Center, Lisbon, the South and the Algarve). All the variables were computed using the same dataset.

[10]In the computation of the firm's average education we exclude the worker's own education, in order to avoid multicolinearity problems.

In appendixes A1 and A2 we show some descriptive statistics of the sample, before displacement (at $t-1$) and after displacement (at t), respectively. It is interesting to note that 10% of the workers were employed in large firms, before displacement, and 20% after displacement. This means that mobility takes place, mainly from small to large firms, after displacement. As we can see in Appendix A1, large firms, with more than 499 employees, pay, on average, roughly more 0.50 log points than small firms. Large firms also have a more skilled workforce (with 8.16 average years of education, comparing to 6.75 in small firms, before displacement), but with similar ages. Workers in small firms are mainly in manufacturing, while trade is the predominant sector for workers in large firms.

4 Results

The GMM estimates (based on first moments) are reported in column 2 of Table 1. We also present an estimation with the constraint $\psi = 0$ being imposed, in column 1. In this case, the model is equivalent to the first-differenced specification, commonly used in panel data studies.

[*Table 1 here*]

Concerning the first estimation, the elasticity of the firm size relative to worker's wage is positive and significant, and equal to 0.034. This means that doubling the firm size implies an average wage increase of 2.2%. Relaxing the $\psi = 0$ assumption, in column 2, the estimated wage gap, in terms of elasticity, is reduced to 0.020. These results are consistent with the ones reported in the table by Brown and Medoff (1989) (range 0.021-0.032), for US longitudinal data.

The coefficients of observed characteristics can only be identified if these vary though time (as tenure) or interacted with the firm size indicator, if the latter changes between the two periods. We report only the interactions coefficients. The other estimates are reported in Appendix B. We find a mixed effect of size of firms on the prices of these attributes. More educated and older individuals benefit from moving to a large firm, and the price of tenure also increases with firm size. However, the specific returns to managers and high skilled workers are smaller when these workers move from a small to large firm. Also, we report some evidence that the gender wage ratio declines with firm size, which is consistent with the evidence surveyed in Oi and Idson (1999).

Concerning the parameter ψ, the negative value found implies that the price of unobservables decreases as firm size increases. This means that small firms are more willing to pay a premium for worker's ability, than large firms. This an important result, but nevertheless is in the line of previous attempts to control for self-selection and sorting of workers in firms across size spectrum.

The overidentification test is a natural way to test whether the instruments are valid in the sense that they are uncorrelated with the error term in equation (17). In a complicated non-linear model like ours, this test can fail either because the model is mispecified or because the model is well-specified but the instruments are invalid[11]. The statistics reported at the bottom of Table 1 show that we marginally cannot reject the null hypothesis that the overidentification restrictions are inconsistent with the data.

5 Conclusion

This paper extends the available empirical literature on the firm size-wage effect in several ways. We estimate the size-wage gap considering an estimator that extends the standard panel data techniques to the case in which the return to permanent component of the error term is differently rewarded across firm sizes. Also this study uses a very rich employer-employee matched data, and therefore not only can some aspects of the labor demand side be controlled, but also the panel structure of the data to account for the individual unobserved heterogeneity can be exploited. The use of a sample of displaced workers by firms closings, reduces the problems generated by endogenous worker-firm mobility.

Although we are using a different sample in a different national context, our results are consistent with previous findings on the subject. Some of the observed skills, namely education, age and tenure have higher returns in large firms, while the opposite is true for high skilled occupations and for

[11] See Gibbons, et al. (2002), for a discussion about the test in this type of models.

the gender gap.

Also, the price of non-observed skills is reduced as firm size increases. This finding is consistent with explanations based on the premise that large employers have more difficulty monitoring workers, and therefore leads them to monitor less closely (see Stigler (1962) or Garen (1985)). As a result, they are less able to detect the subtler aspects of worker quality (such as effort) and they pay more for workers of given quality. Small firms have greater ability to monitor, and hence they can reward the best workers.

Finally, future research should include the comparison of this approach with a model that accounts explicitly for the sample selection bias, as in Vella and Verbeek (1998) or Vella (1998). Since we use a panel of workers and firms, we can decompose the endogeneity underlying firm size choice into an individual-specific component and an individual/time specific effect.

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Table 1: GMM Estimates of the Wage Equation

Dep.Var:	First Diff. Est.		Quasi Diff. Est.	
Log of Hourly Wage (t)	(1)		(2)	
	Coefficient	(Std. Error)	Coefficient	(Std. Error)
Log(size)	0.034***	(0.002)	0.020***	(0.003)
Returns to unobs. skills ψ	0		-0.196***	(0.007)
Returns to observed skills				
inter. with firm size				
Male	0.004**	(0.001)	-0.023*	(0.011)
Managers	-0.007	(0.006)	-0.165***	(0.024)
High Skilled	-0.008*	(0.003)	-0.048***	(0.016)
Skilled	-0.005**	(0.003)	-0.022	(0.015)
Tenure	0.001***	(0.000)	0.001*	(0.000)
College	0.023	(0.005)	0.098***	(0.019)
High School	0.017***	(0.002)	0.100***	(0.011)
Low Sec. School	0.014***	(0.002)	0.048***	(0.007)
Age	0.002***	(0.000)	0.008***	(0.001)
Age sq./1000	-0.026***	(0.002)	-0.058***	(0.006)
Overidentification test			21.042	
(p-value)			(0.101)	
No. of observations	25151		25151	

Estimates were made by fitting the quasi-differenced wage equation (17) by non-linear instrumental variable methods.
Omitted dummy variables: manufacturing, primary school, Lisbon and non-skilled.
The instrumental variables used are all the regressors cited in the text (worker and firm characteristics) plus two period lagged firm characteristics (region, firm size, sector, ownership status, av. education, log sales and tenure).
*** Significance level lower than 1%, ** significance level lower than 5%, * sig. level lower that 10%.

Source: Portuguese Ministry of Labor and Solidarity, "Quadros de Pessoal" Dataset.

Appendix A1: Descriptive Statistics by Firm Size, Before Displacement

Variable	Total (N=25151)	Large (>499)	Small (<500)
Large Firm	9.6%		
Small Firm	90.4%		
Log(wage)	6.42	6.84	6.37
	(0.62)	(0.55)	(0.61)
Worker Characteristics			
Age	38.12	38.11	38.12
	(15.76)	(14.34)	(15.90)
Primary School	65.9%	43.4%	68.3%
Low Secondary School	15.5%	33.9%	13.6%
High School	14.1%	17.7%	13.8%
College	4.4%	5.0%	4.3%
Male	59.7%	55.8%	60.1%
Managers & Exec.	3.4%	3.6%	3.4%
High Skilled	16.4%	20.5%	16.0%
Skilled	67.1%	64.7%	67.3%
Non Skilled	13.1%	11.1%	13.3%
Job Tenure	10.86	11.93	10.76
	(6.26)	(6.33)	(5.35)
Firm Characteristics			
Foreign	9.7%	6.0%	10.0%
Public	0.6%	0.0%	0.7%
Log (Size)	4.09	7.13	3.77
	(1.57)	(0.64)	(1.26)
Log (Sales)	12.00	15.04	11.68
	(4.08)	(3.65)	(3.98)
North	34.8%	35.7%	34.7%
Center	24.3%	26.5%	24.1%
Lisbon	35.2%	34.1%	35.3%
South	2.0%	1.9%	2.0%
Alentejo	3.7%	1.8%	3.9%
Av. Firm Educ.	6.89	8.16	6.75
	(2.41)	(1.45)	(2.45)
Manufacturing	50.3%	17.9%	53.8%
Construction	6.9%	1.1%	7.5%
Trade	26.9%	43.1%	25.2%
Trans. & Commun.	2.7%	0.0%	3.0%
Finance	9.5%	31.9%	7.1%
Other Serv.	3.6%	6.0%	3.4%

Appendix A2: Descriptive Statistics by Firm Size, After Displacement

Variable	Total (N=25151)	Large (>499)	Small (<500)
Large Firm	20.8%		
Small Firm	79.3%		
Log(wage)	6.58	7.03	6.47
	(0.65)	(0.68)	(0.58)
Worker Characteristics			
Age	40.12	41.40	39.35
	(15.68)	(13.14)	(15.06)
Primary School	64.4%	48.1%	68.7%
Low Secondary School	15.9%	26.5%	13.2%
High School	14.9%	19.8%	13.6%
College	4.8%	5.6%	4.6%
Male	59.7%	64.1%	58.5%
Managers & Exec	4.0%	5.5%	3.6%
High Skilled	17.4%	24.1%	15.6%
Skilled	67.0%	61.1%	68.5%
Non Skilled	11.6%	9.2%	12.2%
Job Tenure	1.08	1.16	0.95
	(0.78)	(0.82)	(0.72)
Firm Characteristics			
Foreign	12.4%	19.2%	10.6%
Public	0.4%	1.2%	0.2%
Log (Size)	4.49	7.25	3.76
	(1.92)	(0.71)	(1.41)
Log (Sales)	12.25	15.88	11.30
	(4.45)	(2.82)	(4.31)
North	35.1%	28.7%	36.8%
Center	24.4%	27.5%	23.6%
Lisbon	34.8%	35.9%	34.6%
South	2.0%	3.0%	1.7%
Alentejo	3.7%	4.9%	3.4%
Av. Firm Educ	7.25	8.28	6.98
	(2.48)	(1.73)	(2.57)
Manufacturing	46.6%	33.0%	50.1%
Construction	7.0%	2.1%	8.3%
Trade	27.6%	33.5%	26.0%
Trans. & Commun.	3.3%	1.0%	3.9%
Finance	11.4%	27.0%	7.3%
Other Serv.	3.6%	3.2%	3.7%

Appendix B1 – First-Differences Estimates ($\psi = 0$): All Workers

	Coefficient	Std. Error	t-Statistic	Prob.
Log(Size)	0.034	0.002	15.794	0.000
Age	0.009	0.002	4.818	0.000
Age square/1000	-0.081	0.014	-5.638	0.000
Managers	0.172	0.024	7.147	0.000
High Skilled	0.116	0.012	9.875	0.000
Skilled	0.045	0.007	6.228	0.000
Tenure	0.002	0.000	6.194	0.000
Low Sec. School	-0.007	0.011	-0.595	0.552
High School	-0.003	0.014	-0.207	0.836
College	0.066	0.039	1.707	0.088
Foreign	0.124	0.088	14.038	0.000
Public	0.098	0.034	2.851	0.004
Av. Firm Education	0.018	0.002	8.500	0.000
Log (Sales)	-0.004	0.001	-7.205	0.000
Construction	0.036	0.019	1.867	0.062
Trade	0.014	0.009	1.495	0.135
Transp. & Communic.	0.109	0.027	4.060	0.000
Finance	-0.005	0.019	-0.288	0.774
Other Serv.	0.002	0.020	0.095	0.924
North	0.019	0.003	6.575	0.000
Center	0.012	0.003	4.138	0.000
South	0.005	0.008	0.610	0.542
Algarve	0.0004	0.008	0.047	0.963
Vars Interacted w/ Log(Size)				
Male	0.004	0.001	2.443	0.015
Managers	-0.007	0.006	-1.149	0.251
High Skilled	-0.008	0.003	-2.661	0.008
Skilled	-0.005	0.003	-2.039	0.041
Tenure	0.001	0.000	10.431	0.000
Low Sec. School	0.014	0.002	7.179	0.000
High School	0.017	0.002	7.858	0.000
College	0.023	0.005	4.834	0.000
Age	0.002	0.000	10.365	0.000
Age square/1000	-0.026	0.002	-11.842	0.000
N=25151				
R-squared	0.679	F-statistic		1649.559
Adjusted R-squared	0.679	Prob(F-statistic)		0.000

Appendix B2: GMM Estimates: All Workers

	Coefficient	Std. Error	t-Statistic	Prob.
Log(Size)	0.020	0.003	6.757	0.000
Age	0.008	0.002	3.840	0.000
Age square/1000	-0.072	0.016	-4.420	0.000
Managers	0.102	0.031	3.253	0.001
High Skilled	0.115	0.014	8.347	0.000
Skilled	0.042	0.009	4.554	0.000
Tenure	0.002	0.000	4.504	0.000
Low Sec. School	0.012	0.013	0.945	0.345
High School	0.006	0.016	0.345	0.730
College	0.102	0.047	2.194	0.028
Foreign	0.095	0.010	8.793	0.000
Public	0.055	0.041	1.332	0.183
Av. Firm Education	0.004	0.003	1.444	0.149
Log (Sales)	-0.002	0.001	-2.613	0.009
Construction	0.028	0.020	1.386	0.166
Trade	0.015	0.011	1.366	0.172
Transp. & Communic.	0.121	0.029	4.133	0.000
Finance	-0.016	0.028	-0.588	0.557
Other Serv.	-0.043	0.036	-1.193	0.233
North	0.005	0.003	1.487	0.137
Center	0.002	0.004	0.416	0.677
South	-0.019	0.010	-1.977	0.048
Algarve	0.00002	0.009	0.003	0.998
Vars Interacted w/ Log(Size)				
Male	-0.023	0.012	-1.929	0.054
Managers	-0.165	0.024	-6.824	0.000
High Skilled	-0.048	0.016	-3.065	0.002
Skilled	-0.022	0.015	-1.541	0.123
Tenure	0.001	0.000	1.801	0.072
Low Sec. School	0.048	0.007	6.665	0.000
High School	0.100	0.011	9.144	0.000
College	0.098	0.019	5.283	0.000
Age	0.008	0.001	10.626	0.000
Age square/1000	-0.058	0.006	-10.094	0.000
Ret. to Unobs. (ψ)	-0.196	0.007	-27.059	0.000
N=25151				
R-squared	0.539	J-statistic		0.008
Adjusted R-squared	0.538			

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