Wages and the Risk of Displacement[*]

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November 2004

Abstract

In this paper a simultaneous-equations model of firm closing and wage determination is developed in order to analyse how wages adjust to unfavorable shocks that raise the risk of displacement through firm closing, and to what extent a wage change affects the exit likelihood. Using a longitudinal matched worker-firm data set from Portugal, the results show that the fear of job loss generates wage concessions instead of compensating differentials. A novel result that emerges from this study is that firms with a higher incidence of minimum wage earners are more vulnerable to adverse demand shocks due to their inability to adjust wages downward. In fact, minimum wage restrictions were seen to increase the failure rates.

JEL classification: J31; J65

Keywords: wages; displacement risk; concessions

1 Introduction

The extent of job destruction and, in particular, firm closing and job loss due to sector reallocation, has been a matter of great concern in recent years, with empirical research on gross job flows experiencing a tremendous growth in the past decade. The studies on the decomposition of net employment flows emphasize the importance of job creation and job destruction through the entry and exit of firms. According to Davis *et al.* (1996), about one-fourth of annual job destruction in the U.S. takes places at plants that shutdown, while startups account for one-sixth of annual job creation. In Portugal, annual job flows produced by both plant births and plant deaths account for almost half of total gross employment flows (Blanchard and Portugal, 2001).

However, the literature on flows of jobs is mostly employment accounting, whereas wages/prices and fluctuations in labor demand are never considered. As pointed out by Hamermesh (1993): "...data on gross flows of jobs tell us

nothing directly about the magnitude of the wage or output elasticities of employment changes through the births and deaths of establishments, or growth or contraction in existing establishments."

Recently, a considerable number of studies have been examining how the wages of displaced workers vary (over a long-term period) compared to workers who are not displaced [see, among others, Jacobson *et al.* (1993), Stevens (1997) and Margolis (1999)]. Nonetheless, few studies have yet analyzed how that wage variation affects the probability of displacement. In fact, the theoretical and empirical research on the role of wages on plant closings is remarkably sparse. Most of the empirical literature on plant closings has been concentrated on the effect of unions in the probability that a firm (plant) shuts down.[1]

Hamermesh (1988) was the first who explicitly addressed this issue, developing a model in which workers and firms contract over wages and employment probabilities. Since then empirical research in this area has not seen great improvement.[2]

Hamermesh (1988, 1991 and 1993) modeled the relationship between wage changes and the probability of job displacement due to plant closing, in order to determine the necessary wage concessions to keep plants from closing. The model estimates also allowed him to compute the elasticity of labor demand through plant closings.[3]

The model is set within a theoretical contract framework in which workers contract with their employers for a package that includes a probability that the job will exist and a wage premium above the entry-level wage (reservation wage). In fact, when workers sort themselves among firms, one of the risks they consider is that exogenous product-market shocks may cause the firm to close down. Thus, the workers will choose between the possibility of a higher wage and a reduced risk of firm closing in order to maximize their expected utility. According to the expected exogenous shocks in the product's demand, the firm determines the critical level of profits that assures its continued existence which permits to define the probabilistic shutdown frontier.[4] The equilibrium in the internal labor market is achieved when the workers' indifference curve is tangent to the firm's probabilistic shutdown frontier, for a given product's demand shock.

Hamermesh's model has two main predictions. The first points to a negative relationship between the excess of wages over the reservation wage and the probability of closing, suggesting that shocks that increase the probability of displacement reduce the magnitude of the wage increase.[5] From the perspective of the contractual relationship between employers and employees the role of joint investments in specific training may be viewed as a buffer that can cushion

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[1] See Addison *et al.* (2002, pp. 23-24) for a summary of the international evidence of union effects on plant closings for Britain and the Unites States. Their own study is about the effects of worker representation on plant closings in Germany.

[2] The exceptions are the studies of Dunne and Roberts (1990) and Blanchflower (1991).

[3] For a more detailed approach see Hamermesh (1988, 1991 and 1993).

[4] Thus, the probabilistic shutdown frontier for a given exogenous shock in the product's demand, shows the probability that the plant will close for each wage rate.

[5] Even though, Hamermesh refers that there are some assumptions that may reverse the sign of this relationship. Its sign is, in fact, a matter for empirical work.

against negative shocks and, thus, partially insulate the firm from unfavorable market conditions. That is, since an internal labor market may operate with employers and employees sharing the rents originated by firm-specific human capital, the adjustment to negative shocks may be partially absorbed through wage concessions. The possibility of wage concessions is, of course, precluded if workers are paid legal minimum wages. The second points to the existence of a positive relationship between the reservation wage and the probability of closure due to the existence of compensating differentials for the *ex ante* risk of displacement.

In order to test these predictions, Hamermesh (1998, 1991) used a longitudinal household sample from the Panel Study of Income Dynamics (PSID) that includes 114 workers who left their previous job between 1977-81 because the plant shut down, and 2,433 household heads who were not displaced during this period. His results revealed that shocks that increase the probability of displacement also significantly reduce the wage increase. In other words, average wages grow less rapidly in plants that will soon close, suggesting that firms' adjustment to price shocks are partially absorbed into wages. Concerning the second prediction of the model, no robust evidence was found in favor of the existence of compensating differentials for the *ex ante* risk of displacement. In fact, and contrary to what was expected, a negative coefficient was found for the reservation wage, a finding that Hamermesh interpreted as reflecting the dominance of the income effect of higher earnings on the demand for security.

Based on the theoretical framework of Hamermesh's model, this study will examine how wages adjust to a negative demand shock that raises the risk of displacement through firm closing and to what extent a wage change affects the exit likelihood. The role of a mandatory minimum wage on the firm's exit decision will also be analyzed.

This work attempts to give an additional contribution to the empirical literature on wages and the risk of displacement on three distinct grounds. The first is related to the use of an appropriate and representative data set to analyze the relationship between wages and the risk of displacement. In fact, the Portuguese data from *Quadros de Pessoal* (*QP*) can be described as a longitudinally matched worker-firm sample with a rich set of information on workers' characteristics, their wages, and their work environment. This will enable us to address a number of questions that cannot be adequately answered in the absence of firm or worker data.

The second is related to the use of a simultaneous-equations approach in order to account for the possible endogeneity of wages and the probability of displacement. As it seems clear that an increase in the firms' failure rate may affect wage changes because it raises the risk of displacement, it also seems clear that a wage change may affect the exit likelihood because it reduces, all else being equal, firm's profitability.

Third and finally, this study makes an important contribution by examining the effect of a mandatory minimum wage on the failure rate. Despite the great effort dedicated to research on the effect of minimum wages on unemployment, namely, youth unemployment, we are not aware of any study that explicitly

looks at the relationship between minimum wages and firms' exits. Are firms with a higher proportion of minimum wage earners more vulnerable to product shocks due to their inability to adjust wages downward?

The plan of the paper is as follows. Section 2 presents the simultaneous-equations model of firm closing and wages. In this Section we also develop the basic hypothesis regarding which factors should matter for exit and discuss the wage determinants. In Section 3 the data set is described. Section 4 reports the empirical results and Section 5 concludes.

2 The Empirical Model of Firm Closing and Wages

2.1 Purpose

The empirical model of firm closing and wages presented in this Section attempts to tackle three different questions. The first is to examine how wages adjust to a negative demand shock that raises the probability of displacement through firm closing. The second is to determine how wages themselves affect the exit likelihood. The third is to analyze the effect of a mandatory minimum wage on the failure rate.

With respect to the first issue, the objective is to examine if a higher risk of displacement may lead workers to accept wage concessions or if, on the contrary, that threat leads workers to demand a compensating differential. In fact, in the face of a risk of layoff two forces may be at work. First, workers may demand higher wages in order to compensate them for the higher risk of displacement. This is the prediction of the competitive model with its roots in Smith (1974). Fear of unemployment has to be compensated, like any other disutility, with a wage premium. Second, workers may accept wage moderation (concessions) in order to avoid the firm closing and subsequent displacement. This hypothesis is consistent with the idea that pay is fixed in a bilateral bargain where the fear of unemployment acts to weaken workers' bargaining position [Blanchflower (1991)]. If the first force prevails a positive correlation between wages and the probability of plant closing should be expected. Conversely, if it is the second force that prevails, a negative correlation should be expected.

Concerning the second issue, the effect of wages on firm's profitability, and consequently on firm's survival, is analyzed. The effect of wage levels in the probability of firm closing may be ambiguous. One would expect that all else being equal, firms with lower wages would have higher expected profits, and thus be more likely to survive. However, high wages may simply be viewed as mirroring high productivity and, thus, there might be no correlation.

In the third issue, particular attention will be devoted to the role of minimum wages on firms' closure. In fact, the adjustment to negative demand shocks may be partially absorbed through wage concessions. Nonetheless, the possibility of wage concessions is precluded if workers are paid legal minimum wages. Thus,

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we examine if a mandatory minimum wage imposes severe restrictions in wages adjustment to unfavorable demand shocks that may accelerate the firm's exit decision.

At this point the reasons that led to choosing a model of firm closing and not plant closing should be mentioned. The option to use information at the firm level instead of at the plant level is justified by two main reasons. First, the important management bargaining decisions in a multi-plant firm are made at the corporate level, not at the plant, and reflect the priorities of the firm as a whole. In particular, wage policies are mainly relevant at the firm level. Second, it seems that when it is the firm that is at risk of closing, the unemployment threat is stronger than when it is an establishment of a multi-plant firm. In large multi-plant firms plant shutdowns may be used in addition to layoffs as a means of reducing capacity in the face of unfavorable shocks in the product demand. A plant shutdown may even occur with no layoffs, as workers from closing plants are reemployed in other plants of the same firm. Indeed, in some situations the shutdown of a plant may be a less costly bargaining strategy and, thus, would be preferable to a wage concession strategy. The empirical evidence for Portugal suggests that due to higher adjustment costs (mainly the costs of firing workers) and in the face of unforeseen temporary shocks, it is preferable to employers, under certain circumstances, to close down instead of adjusting their level of employment by laying off workers [Blanchard and Portugal (2001)].

2.2   The Empirical Model

As mentioned above, the three main objectives of the empirical model of firm closing and wages are:

(i) to examine how wages in period *t-1* are affected by a higher risk of displacement due to a threat of firm closure in period t;

(ii) to examine the relationship between the wage paid to an individual worker in the last year on the job (period *t-1)* and the probability that the firm closes in the next year (period t);

(iii) to analyze whether a higher incidence of minimum wage earners in period *t-1* affects the firm's failure rate in period t.

The basic model consists of two equations. The first describes the probabilistic event of a displacement due to plant closure, and is specified from the following equation:

$$\pi^*_{ijt} = \alpha_1 X_{jt-1} + \alpha_2 W^*_{ijt-1} + \alpha_3 \Phi(W_{Mit-1}) + \upsilon_{1ijt} \qquad (1),$$

where $Y_{ijt} = 1$ if $\pi^*_{ijt} < 0$ and $Y_{ijt} = 0$ if $\pi^*_{ijt} \geq 0$.

π^*_{ijt} is a latent variable reflecting the future profitability of firm j. In the data it is not possible to observe π^*_{ijt}. All we can say is whether π^*_{ijt} is or is not below a given threshold (the minimum level of profits that guarantees the firm's continued existence). In the latter case, the firm will continue its

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operations, otherwise it will close down. Thus, the dummy variable Y_{ijt} equals one if worker i was displaced in year t due to firm closure, zero otherwise. The probability of displacement through firm closing is defined as $P_{ijt} \equiv \Pr(\pi^*_{ijt} < 0)$. X_{jt-1} is a vector of firm and local labor market characteristics and W^*_{ijt-1} the natural logarithm of the wage paid to worker i by firm j. $\Phi(W_{Mit-1})$ denotes the probability of a given worker receiving the minimum wage. α's are the parameters to be estimated and υ_{1ijt} is a normally distributed random variable with zero mean and unit variance.

The second equation of the model is a conventional human capital wage equation with controls for local labor market conditions. Generically, the wage equation is defined as:

$$W^*_{ijt-1} = \beta_1 Z_{ijt-1} + \beta_2 U_{jt-1} + \beta_3 \pi^*_{ijt} + \upsilon_{2ijt-1} \tag{2}.$$

where $W_{ijt-1} = Max(W_{Mit-1}, W^*_{ijt-1})$ and W_{Mit-1} is the mandatory minimum wage in period $t-1$.

The wage paid to worker i in firm j is a function of a set of workers' characteristics included in vector Z_{ij}, local labor market characteristics defined in vector U_j and π^*_{ij}. β's are the unknown parameters to be estimated and υ_{2ijt-1} is a normally distributed random variable (zero mean and constant variance).

Even though what determines the stability of employment matches is surplus (i. e, the increment above the entry-level wage), since we are including, in the wage equation, an extensive set of variables that control for workers' characteristics (including tenure on the job) and to some extent to attitudes toward risk, it is indifferent, from a theoretical point of view, to include in the two equations the surplus or the level of wages per se.

2.3   Variables Definition

The dependent variable in the failure equation is a binary variable that takes the value of one if the worker was displaced in year t due to firm closure, zero otherwise. A set of firm variables that may affect the firm's decision to close are identified below.

In order to control the exogenous demand shocks that may affect the probability of firm closing, the average growth rate of real sales in the last three years is used as a proxy for firm-specific shocks.[6] Controlling for firm-specific (idiosyncratic) shocks enables one to examine if, in the face of an identical exogenous shock, and all else being equal, firms with lower wages are less likely to close down or not.

Even though firm demand shifts certainly affect the rate of firm closing, other forces are also at work. Jovanovic (1982) showed that patterns of employer growth and firm (plant) failure are consistent with a process of within-industry selection in which inefficient producers decline and fail. This selection process

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[6]Sales in year t correspond to annual sales of the previous year. Sales were deflated using the CPI (base=1991).

leads to substantial variation in the probability of exit across firms (plants) within an industry. In fact, while plant deaths are part of the normal process of the entry and exit of firms, the post-entry patterns of growth and failure vary considerably with employers' observed characteristics [Dunne *et al.* (1989)]. This reasoning suggests that the risk of displacement due to firm closing varies not only with the demand for the firm's output but also with employer's efficiency relative to competing firms in the same industry. Being so, a set of firm's characteristics that are related to its performance in the output market may affect the firm's own probability of survival. The factors to be included in the empirical model as exit determinants will now be identified. With the exception of past sales growth, all variables are measured in the year that precedes the potential exit event (period *t-1*).

It has been largely shown in the empirical literature on firm survival that firm size and age are negatively associated with failure rates [see, for example, Kumar (1985), Evans (1987), Hall (1987), Dunne *et al.* (1989), Audretsch and Mahmood (1994), Mata and Portugal (1994) and Mata *et al.* (1995)]. These results are consistent with Jovanovic's (1982) model of industry evolution, according to which firms start with no knowledge about their efficiency. As time goes by and firms observe their performance in the output market, they gradually learn about their efficiency. This information is then incorporated into their current size. Efficient firms grow and survive, while inefficient ones contract and fail. Thus, large and old firms are successful firms, and, for this reason, they should have higher survival probabilities.

Thus, measures of the size and age of the firm are included in the failure equation. The size of the firm is defined as the natural logarithm of its total employment. Since the information about the date of a firm's creation is only available after 1993, and in order to use the same criteria to measure age in the 1993-95 period, we used as a proxy for firm age the tenure (in years) of the worker with the longest tenure within the firm.[7] A linear spline function is used to define the effect of the age of the firm.

The firm's market share is used as a measure of product market competition. Monopoly power generates monopoly rents and consequently higher profits. If employers are able to appropriate part of these rents, it should be expected that firms with increased market share are less likely to fail. The market share is obtained by the ratio between a firm's sales and total (5 digit) sector's sales.

Firm ownership characteristics may affect the exit likelihood. Two indicators of ownership type will be used, namely the number of establishments with which each firm operates and the proportion of foreign capital. For the former a dummy variable that takes the value one if the firm is a multi-plant firm (0 otherwise) will be included in the model. Even though the empirical evidence has been showing that multi-plant firms use the shutdown margin more often than their single-plant counterparts, it seems reasonable to admit that exit of a multi-plant firm is less likely since it implies the simultaneous failure of all its

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[7]This solution has been largely adopted and validated by other studies that use the *QP* data set.

plants [see Mata and Portugal (1994), Machin (1995) and the recent studies of Addison *et al.* (2002) and Bernard and Jensen (2002)].

The proportion of foreign capital may itself be an indicator of unobserved quality of the firm and may affect the probability of closure. Doms and Jensen (1998) found that multinational plants have superior observable characteristics. However, it is also well known that multinationals have a higher propensity to relocate production within firms, which may lead to an increased probability of closure [see, for example, Harris and Hassaszadeh (2002)].

If analyzing the effects of individual wage levels on the probability of firm closing, it is necessary to have a measure of revenue per employee in order to be able to compare firms. Firms that have higher variable costs, holding revenue fixed, are less likely to cover their fixed costs in the long-run and thus more likely to close down. Real sales per worker (in logs) is used as a measure of firm's revenue per employee.

Finally, and in order to control for local labor market conditions, a set of industry (one-digit)[8] and regional dummies (NUTs II)[9], as well as the regional unemployment rate, are included in the failure equation. Since the data include firm closures that occurred in 1994, 1995 and 1996, three time dummies were also added to the model in order to control for macroeconomic conditions.

The dependent variable in the wage equation is defined as the natural logarithm of the real monthly base wage paid to an individual worker in the year that precedes the displacement. The monthly base wage was deflated by the Consumer Price Index (CPI; base=1991).

The wage equation includes a set of controls for personal characteristics such as: gender (female=1), education (in years), age and its square (in years), tenure and its square (in years) and qualification level. A set of dummies are used for the levels of qualification. Seven categories are considered: manager and highly professional, professional, supervisors, highly skilled and skilled, semi-skilled and unskilled, non-defined (a residual category) and apprentices (the reference category).

In order to assure that the effect of a higher risk of unemployment on wages is due to firm shutdown and not to differences in the risk of layoff in the local labor markets, the local unemployment rate is used to control for those differences. The local unemployment rate is defined at the disaggregated level of NUTs III.[10] A set of industry (one-digit)[11], regional (NUTs II) and time dummies are also added to the wage equation.

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[8] At one-digit level there are nine sectors according to the Portuguese Classification of Economic Activities (CAE).

[9] At NUTs II mainland Portugal is split into 5 geographical areas.

[10] It should be noted that for the period of analysis of this study (1993-95), unemployment rates are only defined at the regional level at NUTs II. In order to have a proxy for unemployment at a more disaggregated level of NUTs III (28 geographical areas for mainland), the ratio between annual job applications registered in each employment center and total employment (defined at NUTs III using data from QP) will be used.

The information on job applications registered in each employment center was obtained from *Monthly Statistics - Institute for Employment and Vocational Training (IEFP)*.

[11] In this case we employ just 7 sectoral dummies, since the sector of Electricity, Gas and Water, that accounts for a few number of non-displaced workers, was excluded because no

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3 The Data

The data set used in this study was obtained from *Quadros de Pessoal (QP)* and includes all workers that lost their jobs in 1994, 1995 or 1996 due to firm closure and were present in the QP registers in the year that preceded the displacement. A control group constituted by a random sample of workers who were employed in the year prior to the displacement in firms that did not close in the following year is also included.

QP is an annual mandatory employment survey collected by the Portuguese Ministry of Employment, that covers virtually all firms employing paid labor in Portugal.[12] Reported data cover the establishment itself (location, economic activity and employment), the firm (location, economic activity, employment, sales and legal framework) and each of its workers (gender, age, education, skill, occupation, tenure, earnings and duration of work).

The survey has three characteristics that make it particularly suitable for the analysis of the relationship between wages and the risk of firm closing. The first is its coverage. By law, the questionnaire is made available to every worker in a public space of the establishment. This requirement facilitates the work of the services of the Ministry of Employment that monitor compliance of firms with the law (e. g., illegal work). The administrative nature of the data and its public availability implies a high degree of coverage and reliability. Second, this survey is conducted on a yearly basis and since unique identifiers are available for both firms and workers, firms and individuals can be tracked over the years. Third, it contains a rich set of information on both firms and its workers, which will enable us to address a number of questions that cannot be adequately answered in the absence of firm or worker data.

To be sure that exits are accurately identified, we required that a firm be absent from the QP files two or more consecutive years in order to be classified as a closure. Additionally, and to avoid the inclusion of false exits, workers that appeared in the database in the period after displacement with a year of admission in the new job less than the year of displacement minus one were dropped.[13]

In order to be allowed to construct the variables that account for firm's recent evolution, we impose that workers be present in the QP registers in each of the three years that preceded the firm shutdown and employed with the same employer over those years.[14] This requirement means that an individual must have at least two years of tenure in the year prior to displacement. This selection rule, although primarily dictated by data availability considerations,

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plant closings were observed in this sector.

[12] Thus, this source does not cover operated family businesses without wage-earning employees and self-employment. Public administration is also excluded.

[13] If, for example, a worker's displacement year is 1994 and he (she) appears in the database in the post-displacement period with a year of admission in the new job of 1992 or less, he (she) is excluded from the sample.

[14] Hence, for workers displaced in 1994 the data should be available for the 1991-93 period, for workers displaced in 1995 for the period of 1992-94 and for workers displaced in 1996 for the 1993-95 period.

results in an analysis sample of stably employed individuals. On average, the sampled individuals have 26 years of labor force experience and over 11 years of employer tenure.

We also limited the sample to full-time workers aged between 18 and 64 in the year prior to displacement. Since the minimum wage is defined as a monthly wage, the full-time job requirement allows to identify minimum wage earners more accurately. In this context, wages are measured as monthly wages.

We have also excluded those individuals for which information was incomplete for the year before displacement, namely those with zero wage.[15] Finally, and in order to minimize the effects of the presence of outliers, we drop the 0.1% top and the 0.1% bottom observations for the wage and sales variables.

After these exclusions we obtained a sample of 35,922 full-time workers that were displaced between 1994-96 due to firm closing, aged between 18-64 and with at least two years of tenure in the year prior to displacement.

The control group includes three sub-samples and was constructed in the following way. For each year prior to the displacement year we obtained a random sample of around 300,000 workers that were employed in firms that did not close.[16] For each of these three groups we excluded those individuals that were not present in the QP files in each of the three years before displacement and those who were not employed in the same firm over those years. The sample was also limited to full-time workers aged between 18-64 in the year prior to displacement. After excluding those observations with missing values on the explanatory variables and the extreme observations (outliers) for wages and sales, we obtained a control group of 230,102 non-displaced workers.

Table 1 presents the descriptive statistics of the sample for the two groups of workers: displaced and non-displaced. As can be seen in Table 1, on average, displaced workers are slightly younger, less qualified and with fewer years of tenure and education. They also earn, on average, less than non-displaced workers. The pool of displaced workers includes more females and minimum wage earners.

According to firms' characteristics, the proportion of displaced workers that comes from small, young and single-plant firms is higher when compared to the sample of non-displaced workers. For the former the real average growth rate of firms' sales in the last three years is negative (-7.6%), while for the latter that same rate is positive (1.4%). Displaced workers are also employed in firms with a reduced market power (measured by market share).

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[15] For the three years before displacement in the case of the variable sales.

[16] The sample was drawn according to a normal random number generator.

Table 1: Sample Characteristics (Means and Standard Deviations)

	Displaced		Non-displaced	
	Mean	St. Dev.	Mean	St. Dev.
Workers' Characteristics				
Age (in years)	37.3	0.113	38.5	0.107
Tenure (in years)	9.8	0.082	11.9	0.085
Education (in years)	5.8	2.830	6.4	3.231
Proportion of Female	0.442		0.368	
Proportion of Minimum Wage Earners	0.143		0.056	
Qualification Levels (proportion of workers)				
Manager and Highly Professional	0.018		0.029	
Professional	0.017		0.031	
Supervisors	0.051		0.057	
Highly Skilled and Skilled	0.527		0.543	
Semi-skilled and Unskilled	0.279		0.262	
Apprentices	0.057		0.034	
Non-defined	0.051		0.044	
Firms' Characteristics				
Size (total employment)	108.4	426.2	1135.1	2701.2
Past Sales Growth	-0.076	0.391	0.014	0.354
Market Share	0.013	0.060	0.118	0.250
Proportion of Foreign Capital	0.031	0.161	0.094	0.269
Proportion of Multi-plant Firms	0.165		0.413	
Firm Age (proportion of workers)				
2-5 years	0.134		0.046	
6-10 years	0.181		0.086	
> 10 years	0.685		0.869	
Real Sales per Worker (in logs)	8.419	1.111	8.825	1.172
Real Monthly Wage (in logs)	10.973	0.432	11.175	0.490
Number of Observations	35,922		230,102	

Notes: (i) all variables, except past sales growth, are measured in the year prior to displacement; (ii) sales per worker and the monthly wage are in 1991 PTE (escudo); 1 EURO≡200.482 PTE.

4 Estimation and Empirical Results

4.1 Estimation Method

In order to estimate the simultaneous-equations model of firm closing and wages presented in Section 2, it will be necessary to choose an adequate method of estimation. It is well known that the ordinary least squares (OLS) estimator is generally inconsistent when applied to a structural equation in a simultaneous-equations system.

Beyond this difficulty, our empirical model of firm closing and wages has a particularity, since one of the endogenous variables is a binary variable while the other is a censored variable. In fact, while the failure equation is specified as a probit model, the wage equation is a tobit model with lower censoring at the minimum wage. Thus, we are in the presence of a simultaneous-equations model with mixed dichotomous and censored variables.

The conventional method for estimating simultaneous-equations models is the method of instrumental variables. As suggested by Maddala (1983, p. 246), a two-stage procedure will allow us to estimate a two-equation model in which one of the variables is censored while the other is only observed as a dichotomous variable. The two-stage estimation method involves the following steps. The first step is to write the reduced-forms equations for the endogenous variables. Next, estimate the reduced-forms equations and keep the predicted values. Finally, estimate the structural equations replacing the endogenous variables by the predicted values obtained from the reduced-forms regressions.

The empirical model defined by equations (1) and (2) specifies both the probability of closure and wages as endogenous. Hence, the reduced form of the equation system in the latent variables is:

$$\pi_{ijt}^* = \Pi_1 K_{ijt-1} + \varepsilon_{1ijt}, \qquad Y_{ijt} = 1(\pi_{ijt}^* < 0) \tag{3},$$

$$W_{ijt-1}^* = \Pi_2 K_{ijt-1} + \varepsilon_{2ijt-1}, \qquad W_{ijt-1} = Max(W_{Mit-1}, W_{ijt-1}^*) \tag{4}.$$

where K includes all the exogenous variables in X, Z, and U.

The reduced-form parameters can be estimated by applying maximum likelihood to the probit and tobit models in equations (3) and (4), respectively.

Estimating the reduced-form for π_{ijt}^* by the probit method will allow us to obtain the predicted probability of displacement through firm closing, $\widehat{P}$. Estimating the reduced-form for W_{ijt-1}^* by the tobit method will enable us to obtain the predicted value of the monthly wage $(\widehat{W^*})$ and the estimated probability that a given observation is a limit observation, $\Phi(\widehat{W_M})$. In other words, $\Phi(\widehat{W_M})$ measures the estimated probability of a given worker receiving the minimum wage.

This procedure is unconventional, but provides a simple and elegant solution to the specification of the two sources of endogeneity from wages to failure rates. On the one side, the impact of the level of wages on the chances of firm closure.

And, on the other side, the influence of minimum wage restrictions on the ability to accommodate negative shocks.

The structural wage equation is estimated in the second-stage tobit after replacing the probability of displacement through firm closing (P) by its predicted value ($\widehat{P}$). The structural failure equation is estimated in the second-stage probit after replacing the monthly wage (W^*) by its predicted value ($\widehat{W^*}$) and after including the estimated probability of being a minimum wage earner, $\Phi(\widehat{W_M})$. This last procedure will enable us to examine the effect of a mandatory minimum wage on the failure rate.

4.2 Empirical Results

4.2.1 Main Results

The parameter estimates of the simultaneous-equations model of firm closing and wages are presented in Tables 2 (structural failure equation) and 3 (structural wage equation).[17] The estimation strategy consists of having, as far as possible, a complete set of controls to examine whether a robust association between wages and the probability of firm closing (and *vice-versa*) can be identified. The variables that characterize employers' performance such as past sales growth, firm size, firm age, market share, multi-plant firm, proportion of foreign capital and sales per worker contribute to the identification of the wage equation. In the structural probit model of firm closing, the variables that characterize workers' characteristics such as gender, education, age (and its square), tenure (and its square) and the qualification levels are omitted.

Columns 1 and 2 of Table 2 report results (coefficients estimates and marginal effects, respectively) for a specification in which the probability of firm closing depends on an extensive set of firm characteristics, the regional unemployment rate, monthly wages (predicted) and the estimated probability of being a minimum wage earner. A set of dummy variables for industries, regions and years are also included.

According to Table 2, past sales growth, firm size, age, market share, multi-plant firm, proportion of foreign capital and sales per worker are significantly correlated with the probability of firm closing. In particular, the results reveal that firms experiencing a decline in sales growth are clearly more likely to close. This seems to imply that sales contraction can be used as a strong predictor of firm failure. Indeed, the fact that a firm has grown in the past signals that it has been performing well. Moreover, the estimates reported in Table 2 show that small firms are clearly more likely to close than large firms. This result is conventional enough and, in particular, is in line with the one obtained for Portugal in the study of Mata *et al.* (1995) using a sample of newly born manufacturing plants.

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[17]The econometric results were obtained using LIMDEP version 8.0. In both equations the t-ratios correspond to the corrected covariance matrix for the two-step estimator using the methodology developed by Murphy and Topel (1985).

The estimates of the coefficients on firm's age using splines indicate a negative and significant effect of age on the probability of displacement. However, after a decade the negative effect of age starts to vanish, becoming positive for very old firms (more than 54 years).

The variable market share has a strong negative effect on the probability of closing, suggesting that monopoly power generates rents that may function as a buffer that cushions against negative shocks.

As expected, workers that are part of a multi-plant firm are less likely to be displaced due to firm closing than workers that are part of a single-plant firm. The same is true for workers that are part of firms with a large proportion of foreign-owned capital.

Sales per worker, a proxy for productivity, have a negative impact on the probability of firm closing. Thus, low productivity firms, all else being equal, are more likely to close down.

The coefficient estimate of the regional unemployment rate is positive and statistically significant, suggesting that local economic conditions may affect the viability of some types of firms.

High-wage paying firms face higher hazard rates than low-paying firms, *ceteris paribus*. After controlling for an extensive set of employers' characteristics and for local labor market characteristics, the results reveal that firms that pay higher wages, holding revenue per employee fixed, are less likely to survive. In fact, the marginal effect of a 1% increase on monthly wages in the probability of displacement is 0.00008 (see column 2 of Table 2). Since the average job displacement rate through firm closing in the population is around 6.3%, a 1% wage increase is associated with a 0.13% increase in the probability of job displacement through firm closing.

Finally, the two-step probit results report a positive and significant effect of the probability of receiving the minimum wage on the failure rate, suggesting that firms with a higher incidence of minimum wage workers face higher exit rates than those with a smaller incidence. A one point increase in the proportion of minimum wage earners increases the probability of displacement by 0.027 percentage points. Since, on average, the proportion of minimum wage earners in the population is around 13% and the average job displacement rate is 6.3%, a 1% increase in the proportion of minimum wage earners increases the probability of displacement through firm closing by 0.056%.

In fact, the possibility of wage concessions is precluded if workers are paid legal minimum wages.[18] Thus, firms with a higher proportion of minimum wage earners may have lower chances of survival due to their inability to adjust wages downward in the face of a negative demand shock.

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[18]In Portugal, the ratio between minimum wages and average wages is around 43%.

Table 2: Failure Equation - Two-step Probit Results
Full-time Workers (N=266024)
Dependent variable: displaced=1

Variables	Coefficient	Marginal Effect
Past Sales Growth	-0.327	-0.049
	(-31.1)	
Firm Size	-0.241	-0.036
	(-77.2)	
Firm Age		
Age	-0.059	-0.009
	(-5.3)	
AgeS5	-0.007*	-0.001
	(-0.6)	
AgeS10	0.073	0.011
	(24.7)	
Market Share	-1.434	-0.217
	(-28.9)	
Multi-plant Firm	-0.065	-0.010
	(-6.8)	
Proportion of Foreign Capital	-0.204	-0.031
	(-11.3)	
Sales per Worker	-0.055	-0.008
	(-13.7)	
Regional Unemployment Rate	0.054	0.008
	(7.3)	
Monthly Wage (predicted)	0.052	0.008
	(2.6)	
$\Phi(W_M)$ (predicted)	0.181	0.027
	(5.4)	
Constant	0.860	0.130
	(3.9)	
Log-likelihood	-88630.3	
Chi-squared	33347.0	

Notes: (i) a set of industry, regional and time dummies are included in the specification;
(ii) AgeS5=(Age-5) if Age>5, 0 otherwise; AgeS10=(Age-10) if Age>10, 0 otherwise;
(iii) t-ratios are in parentheses;
(iv) all estimates are significant at 1%, except those with an *.

Table 3 reports the two-step tobit results of the wage equation. The basic specification includes a set of controls for workers' characteristics, the regional unemployment rate and the instrumented probability of displacement due to firm closing. A set of industry, regional and time dummies are also included in the specification. All the exogenous variables (excluding tenure squared) are statistically significant at the 1% level of significance and have the expected signs.

The effect of the probability of closing on monthly wages is negative and also statistically significant. This implies that a worker employed in a firm that will close earns less in the year prior to displacement than a similar worker employed in a non-closing firm. Converting the coefficient of -0.892 to an elasticity results in a value of -0.056 evaluated at the mean failure rate in the sample. In other words, workers in a firm that has the average probability of failure in the population (6.3%), earn (one year prior to closing) 5.6% less than workers in a firm with zero probability of failure (a useful artificial benchmark).[19] This empirical result indicates the existence of wage concessions for workers employed in firms with a higher probability of failing.[20]

This empirical evidence seems to contradict the theoretical prediction that workers employed in firms with a higher probability of displacement require a compensating differential for the risk of layoff. The compensating differential for the *ex ante* risk of displacement may exist. The evidence of a positive relationship between wage levels and failure rates reported in the probit equation is consistent with the existence of higher wages due to compensating differentials, that may accelerate in the short-run the process of closure. However, the results obtained from the wage equation seem to suggest that in the face of an *ex post* risk of displacement the compensating differential for the risk of layoff is offset by the need to moderate wages in order to avoid the firm's shutdown.

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[19] If $\widehat{W_1}$ is the predicted wage in a firm with an average failure probability of 0.063 and $\widehat{W_0}$ is the predicted wage in a firm that has no probability of failing, then the relative wage differential is calculated as $\ln(\widehat{W_1}/\widehat{W_0}) = [(-0.892) * (0.063)] = -0.056$.

[20] It should be noted that in Portugal it is not allowed, in no circumstances, to reduce nominal wages. Thus, here the term "wage concessions" refers to cuts in the growth rate of real/nominal wages.

Table 3: Wage Equation - Two-step Tobit Results
Full-time Workers (N=266024)
Dependent variable: log of real monthly wage

Variables	Coefficient	Marginal Effect
Female	-0.170	-0.162
	(-86.5)	
Education	0.054	0.051
	(118.4)	
Age/100	2.873	2.745
	(44.0)	
Age/100 Squared	-2.712	-2.592
	(-33.8)	
Tenure/100	0.331	0.317
	(7.9)	
Tenure/100 Squared	-0.093*	-0.089
	(-0.8)	
Qualification Levels		
Manager and Highly Professional	0.762	0.728
	(62.4)	
Professional	0.575	0.549
	(61.2)	
Supervisors	0.445	0.425
	(58.5)	
Highly Skilled and Skilled	0.214	0.204
	(33.7)	
Semi-skilled and Unskilled	0.089	0.086
	(13.8)	
Non-defined	0.377	0.361
	(43.9)	
Regional Unemployment Rate	-0.058	-0.056
	(-25.1)	
Probability of Displacement (predicted)	-0.933	-0.892
	(-75.7)	
Constant	10.064	9.616
	(703.7)	
Log-likelihood	-82468.0	
$\widehat{\sigma}$	0.32	

Notes: (i) a set of industry, regional and time dummies are included in the specification;
(ii) t-statistics are in parentheses;
(iii) all estimates are significant at 1%, except those with an *.

5   Conclusion

In this paper we have investigated how wages adjust to unfavorable shocks that raise the risk of displacement through firm closing, and to what extent a wage change affects the exit likelihood. For this purpose, a simultaneous-equations model was applied to a large longitudinally linked employer-employee data set of workers displaced due to firm closing. Three main conclusions emerge from this exercise.

First, after controlling for employers' heterogeneity and local labor market conditions, the results indicated that, although modest, wages have a positive impact on the failure rate. High-wage paying firms face higher exit rates than low-paying firms, *ceteris paribus*. Indeed, a 10% increase in monthly wages raises the probability of displacement through firm closing by 1.3%.

Second, a negative and strong effect of the probability of closing on wages was found, favoring the hypothesis that the risk of unemployment depresses wages. Workers employed in firms at risk earn around 6% less one year prior to closing than workers in firms with no risk of closure. This robust empirical evidence reinforces the hypothesis that instead of requiring a compensating differential for a higher risk of displacement, workers in firms at risk are able to agree upon wage concessions/moderation in order to avoid the firm's shutdown.

Third, minimum wage restrictions were seen to increase the failure rates. A high proportion of minimum wage earners in a firm may preclude the possibility of wage concessions in response to unfavorable shocks, and thus accelerate the exit decision. In other words, firms with a higher incidence of minimum wage earners are more vulnerable to adverse demand shocks due to their inability to adjust wages downward. In fact, beyond the direct effect of wages on the failure rate, a 10% increase in the incidence of minimum wage earners (around 1.3 percentage points) raises the probability of displacement by 0.56%.

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