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WAGE DYNAMICS NETWORK

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WAGES AND THE RISK OF DISPLACEMENT

by Anabela Carneiro and Pedro Portugal

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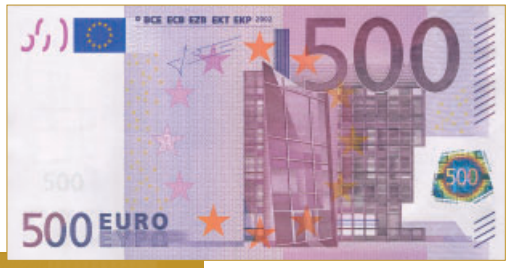
WAGES AND THE RISK OF DISPLACEMENT [1]

by Anabela Carneiro [2]

and Pedro Portugal [3]



In 2010 all ECB publications feature a motif taken from the €500 banknote.

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2 Faculdade de Economia da Universidade do Porto, Rua Dr. Roberto Frias, 4200-464 Porto, Portugal and CETE; e-mail: anacar@fep.up.pt. CETE is a Research Centre supported by Fundação para a Ciência e a Tecnologia, Programa de Financiamento Plurianual through the Programa Operacional Ciência, Tecnologia e Inovação (POCTI)/ Programa Operacional Ciência e Inovação 2010 (POCI) of the III Quadro Comunitário de Apoio, which is financed by FEDER and Portuguese funds.

3 Banco de Portugal, Av. Almirante Reis 71, 6th Lisbon 1150-012, Portugal and Universidade Nova de Lisboa; e-mail: pportugal@bportugal.pt

Wage Dynamics Network

This paper contains research conducted within the Wage Dynamics Network (WDN). The WDN is a research network consisting of economists from the European Central Bank (ECB) and the national central banks (NCBs) of the EU countries. The WDN aims at studying in depth the features and sources of wage and labour cost dynamics and their implications for monetary policy. The specific objectives of the network are: i) identifying the sources and features of wage and labour cost dynamics that are most relevant for monetary policy and ii) clarifying the relationship between wages, labour costs and prices both at the firm and macro-economic level.

The WDN is chaired by Frank Smets (ECB). Giuseppe Bertola (Università di Torino) and Julian Messina (Universitat de Girona) act as external consultants and Ana Lamo (ECB) as Secretary.

The refereeing process of this paper has been co-ordinated by a team composed of Gabriel Fagan (ECB, chairperson), Philip Vermeulen (ECB), Giuseppe Bertola, Julian Messina, Jan Babecký (CNB), Hervé Le Bihan (Banque de France) and Thomas Mathä (Banque centrale du Luxembourg).

The paper is released in order to make the results of WDN research generally available, in preliminary form, to encourage comments and suggestions prior to final publication. The views expressed in the paper are the author's own and do not necessarily reflect those of the ESCB.

Address
Kaiserstrasse 29
60311 Frankfurt am Main, Germany

Postal address
Postfach 16 03 19
60066 Frankfurt am Main, Germany

Telephone
+49 69 1344 0

Website
http://www.ecb.europa.eu

Fax
+49 69 1344 6000

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Abstract

In this paper a simultaneous-equations model of firm closing and wage determination is specified in order to analyse how wages adjust to unfavorable product demand shocks that raise the risk of displacement through firm closing, and to what extent an exogenous wage change affects the exit likelihood. Using a longitudinal matched worker-firm data set from Portugal, the estimation results suggest that, under the existence of non-competitive rents, the fear of job loss leads workers to accept wage concessions, even though a compensating differential for the *ex ante* risk of displacement might exist. A novel result that emerges from this study is that firms with a higher incidence of minimum wage earners are more vulnerable to adverse shocks due to their inability to adjust wages downward. Indeed, 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 and worker flows experiencing a tremendous growth over the past two decades. 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 shut down, 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).

The literature on flows of jobs is, however, mostly employment accounting, without any direct information 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 examined how the wages of displaced workers evolve (over a long-term period) in comparison with the wages of workers who were not displaced [see, among others, Jacobson *et al.* (1993), Stevens (1997) and Margolis (1999)]. Nonetheless, few studies have yet analyzed how exogenous wage changes affect 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 concentrated on the effect of unions in the probability that a firm (plant) shuts down.[1]

Hamermesh (1988) was the first to address this issue explicitly, offering a model in which workers and firms contract over wages and employment probabilities.[2]

Based on the theoretical framework of Hamermesh's model (1988, 1991 and 1993), 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 wages affect the exit likelihood. The role of a mandatory minimum wage on the firm's exit decision will also be analyzed.

This work attempts to contribute to the empirical literature on wages and the risk of displacement on three distinct grounds. The first 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 firm's 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, the firm's profitability.

Second, this study makes a significant 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?

Finally, the third 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

[1] See Addison *et al.* (2004) for a summary of the international evidence of union effects on plant closings for Britain and the United States. Their own study is about the effects of worker representation on plant closings in Germany.

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

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 plan of the paper is as follows. Section 2 presents the theoretical framework. Section 3 describes the empirical counterpart of the simultaneous-equations model of firm closing and wages. In Section 4 the data set is described and the basic hypothesis regarding which factors should matter for exit and the wage determinants are also discussed. Section 5 reports the empirical results and some tantalizing robustness checks. Section 6 concludes.

2 Theoretical Framework

Hamermesh's theoretical model (1988, 1991 and 1993) constitutes the basis of our own approach. Hamermesh 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.[3] The model is set within a contract theory 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.

The idea underlying the model is that 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.

Thus, in a given period t, the level of wages includes two components and can be defined as:

$$W_t = W_{Rt} + (W_t - W_{Rt})$$

The first component corresponds to the reservation wage, W_{Rt}, the market wage rate that makes the worker indifferent between that firm and at least another one. The reservation wage includes a compensating differential for the *ex ante* expected probability of closing. The second component, $W_t - W_{Rt}$, corresponds to the deviation of wages over the reservation wage and should reflect the returns to firm-specific human capital investments.

Two main predictions emerge from Hamermesh's model. 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. 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.

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

In order to disentangle between these two effects, i. e., to analyze how wages adjust to unfavorable shocks that raise the risk of displacement through firm closing, and to what extent an exogenous wage change affects the exit likelihood, a simultaneous-equations model of firm closing and wage determination is adopted in this study.

In this framework wages are determined through negotiation between the firm and its workers. It is also assumed that the existence of product/labor market power generates rents that can be shared by employees in the form of higher wages. From the perspective of the contractual relationship between employers and employees, the existence of non-competitive rents may be viewed as a buffer that can cushion against negative shocks and, thus, partially insulate the firm from unfavorable market conditions. The possibility of wage concessions is, of course, precluded if workers are paid legal minimum wages.

The basic model consists of two equations. In essence, the first defines the probabilistic event of a displacement due to plant closure. This equation is a discrete labor demand function that describes the impact of wages on the probability of displacement through firm closing and, thus, on employment. The effect of wage levels on 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. But, in the absence of proper productivity measures, high wages may simply be viewed as mirroring high productivity and, thus, there might be no correlation.

The second equation of the model is a wage bargaining function. The market-wage equation allows us to examine whether, under imperfect competition in the labor market, the risk of being fired due to firm closing leads workers to accept wage moderation in order to avoid the firm's shutdown. 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)].

3 The Empirical Model of Firm Closing and Wages

3.1 Purpose

The empirical model of firm closing and wages presented in this Section attempts to grasp three important elasticities. The first will give a measure of how wages adjust to a negative demand shock that raises the probability of displacement through firm closing - elasticity of wages with respect to the probability of firm closure. The second will determine how wages themselves affect the exit likelihood - *quasi*-elasticity of firm closure with respect to wages. The third, measures the effect of a mandatory minimum wage on the failure rate - *quasi*-elasticity of firm closure with respect to minimum wage incidence.

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 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 for employers, under certain circumstances, to close down instead of adjusting their level of employment by laying off workers [Blanchard and Portugal (2001)].

3.2 The Empirical Model

The failure equation is specified as:

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

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 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^*_{Rijt-1} the natural logarithm of the entry-level wage (reservation wage) paid to worker i by firm j. We decided to include the level of reservation wages instead of the level of wages per se in the failure equation in order to make comparisons across firms less ambiguous. Adjusting the level of wages by subtracting the impact of tenure circumvents the possibility that wages may be merely reflecting the impact of firm-specific human capital investments on the failure rate.[4] $\Phi(W_{Mit-1})$ denotes

[4] To better understand the relationship between firm-specific human capital and plant closing see Hamermesh (1988).

the probability of a given worker receiving the minimum wage.[5] α's are the parameters to be estimated and υ_{1ijt} is a normally distributed random variable with zero mean and unit variance.

This specification is fundamentally different from Hamermesh's own empirical failure equation. In fact, since a control for firm-specific demand shocks is added to the failure equation defined in (1), the probit equation merely captures the effect of the level of wages on the probability of closing. The failure equation gives, for each wage rate, the probability that the firm will close, holding product demand shocks constant. In this sense, it can be viewed as a discrete version of a labor demand equation. The effect of the probability of closing on wages is estimated in the market wage equation, which can be interpreted as a discrete version of a labor supply equation.

Generically, the market-wage equation is defined as:

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

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}.[6] β's are the unknown parameters to be estimated and υ_{2ijt-1} is a normally distributed random variable (zero mean and constant variance).

4 The Data

4.1 Sample Description

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 made up of 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.[7] Each year, every establishment with wage earners in the private sector is legally obliged to file a standardized questionnaire. Reported data cover the establishment itself (location, economic activity and employment), the firm

[5] Even though minimum wage earners can be identified directly, the estimated probability of a given worker receiving the minimum wage will be included in the probit equation in order to account for the endogeneity of wages, including minimum wages.

[6] Notice that since a control for tenure in the job will be included in the wage equation it is indifferent, from a theoretical point of view, whether the dependent variable is defined as the level of wages (W) or the excess of wages over the reservation wage ($W - W_R$).

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

(location, economic activity, employment, sales and legal framework) and each of its workers (gender, age, education, skill, occupation, tenure, earnings and duration of work).

Each firm entering the database is assigned a different identification number and the Ministry implements several checks to ensure that a firm that has already reported to the database is not assigned a different identification number. In particular, an exit from the database should signal a firm that has ceased its activity. This criteria, however, is not entirely accurate, due to the fact that some of the firms temporarily exit the database. A temporary exit may occur for a number of reasons other than cessation of activity, a very likely reason being that the survey form was not received in the Ministry of Employment before the date when the recording operations were closed. Almost all of these temporary exits last less than two years, but can still cause an identification problem if they occur in the terminal years. In order to account for this problem, the information on the last two years after displacement was used solely to control for temporary exits in the intermediate years.[8] To ensure that we are in the presence of firms' true closures and not mergers or acquisitions, we also excluded from the sample those 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.[9]

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.

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.[10] 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, results in

[8] Since we have information over the 1991-1998 period, a firm is classified as an exiting firm in 1996 if it is present in the QP files in 1995, but absent in 1996, 1997 and 1998. The same reasoning applies for exits in 1994 and 1995.

[9] 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.

[10] 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.

an overrepresentation of employed individuals with a stable contractual relationship.[11] Nevertheless, this restriction should not be of greater concern since the possibility of wage concessions is particularly relevant for workers with a higher employment attachment. 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 us to identify minimum wage earners more accurately.[12] In this context, wages are measured as monthly wages.

We have also excluded those individuals for whom information was incomplete for the year before displacement (or for the three years before displacement in the case of the variable sales), namely those with no reported wage. 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.[13] 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 shown 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 subsample 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 (as measured by market share).

[11] We also believe that this restriction minimizes a potential selectivity problem generated by the (possibly non-random) departure of workers before closure.

[12] See Appendix A for a more detailed description of the minimum wage legislation in Portugal.

[13] The sample was drawn using a 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)				
Top Executives	0.018		0.029	
Intermediary Executives	0.017		0.031	
Supervisors	0.051		0.057	
Highly Skilled and Skilled Professionals	0.527		0.543	
Semi-skilled and Unskilled Professionals	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: (a) all variables, except past sales growth, are measured in the year prior to displacement; (b) sales per worker and the monthly wage are in 1991 PTE (escudo); 1 EURO≡200.482 PTE.

4.2 Variables Definition

4.2.1 Failure Equation

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.[14] Controlling for firm-specific (idiosyncratic) shocks enables one to examine whether, 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 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. In this sense, a set of firm 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 firm 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 product 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. Measures of the size and age of the firm are, thus, 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

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

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.[15] 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) industry 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 suggests 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 plants [see Mata and Portugal (1994), Machin (1995) and the recent studies of Addison *et al.* (2004) and Bernard and Jensen (2002)].

The proportion of foreign capital may itself be an indicator of the firm's unobserved managerial ability and may affect the probability of closure. Doms and Jensen (1998) found that multinational plants have superior observable characteristics. But, 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)].

To analyze the effects of individual wage levels on the probability of firm closing, it is necessary to use 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) and regional dummies (Nuts II), as well as the regional unemployment rate, are included in the failure equation.[16,17] Since the data include firm closures that occurred in 1994, 1995 and 1996, two time dummies were also added to the model in order to control for aggregate economic conditions.

4.2.2 Wage Equation

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

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

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

[17] At Nuts II mainland Portugal is split into 5 geographical areas.

that precedes the displacement. The monthly base wage was deflated by the Consumer Price Index (CPI; base=1991). The reservation wage is measured as the monthly base wage minus an adjustment equal to the effect of tenure (and its square) on wages.

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: top executives, intermediary executives, supervisors, highly skilled and skilled professionals, semi-skilled and unskilled professionals, 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.[18] A set of industry (one-digit), regional (Nuts II) and time dummies are also added to the wage equation.

[18] 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).*

5 Estimation and Empirical Results

5.1 Estimation Procedure

In order to estimate the simultaneous-equations model of firm closing and wages presented in Section 3, it will be necessary to choose an adequate method of estimation. It is well known that the ordinary least squares (OLS) estimator is, in general, inconsistent when applied to a structural equation in a simultaneous-equations system.

Beyond this difficulty, our empirical model of firm closing and wages is non-standard, 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), 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 maximum likelihood methods applied 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 hand, the impact of the level of wages on the chances of firm closure, and, on the other, 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 reservation wage (W_R^*) by its predicted value $\widehat{W_R^*} = \widehat{W^*} - (\hat{\pi}_{21} Tenure - \hat{\pi}_{22} Tenure^2)$ and after including the estimated probability of being a minimum wage earner, $\Phi(\widehat{W_M})$.[19] This last procedure will enable us to examine the effect of a mandatory minimum wage on the failure rate.

5.2 Identifiability Issues

The specification of our simultaneous equation model is based, as usual, on a delicate compromise between parsimony, on the one hand, and the informational limitations of the data, on the other. It has to be admitted from the outset that the identification obtained from the non-linearities of the model, while helpful, is not fully convincing. Apart from this source of identification, we rely on the information of the firm's past sales growth as an indication of exogenous demand shocks which arguably affect the closure decision but not the wage equation. What is assumed is that past sales growth solely impact on wages through the increase of the probability of firm closure (raising the "fear of unemployment" and weakening workers' bargaining power). In short, we are using past sales growth as a valid instrument for the probability of closure and we are confident that the unemployment threat can be legitimately captured in the probability of closure.

By the same token, we included the worker qualification levels, which are used to define the base wages determined by collective bargaining, in the wage equation but not in the failure equation. We are fairly confident that this classification is orthogonal to the exit decision by the firm, being, in our interpretation, a proxy for bargained wages. We also made, with some trepidation, additional exclusion restrictions: in essence, we excluded from the wage equation variables characterizing the firm and we excluded worker variables from the failure equation. These restrictions are admittedly ad-hoc but do not play any decisive role in the estimation results as we shall see.

[19] The estimates of the tenure coefficients ($\hat{\pi}_{21}$and $\hat{\pi}_{22}$) were obtained with the estimation of the reduced form for W^*.

5.3 Empirical Results

5.3.1 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).[20] 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.

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 reservation wage (predicted) and the estimated probability of being a minimum wage earner. A set of dummy variables for industries, regions and years are also included.

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 conditions, the results reveal that firms that pay higher entry-level wages, holding revenue per employee fixed, are less likely to survive. In fact, the marginal effect of a 10% increase on the monthly reservation wage in the probability of displacement is 0.1 percentage points (see column 2 of Table 2). Since the average job displacement rate through firm closing in the population is around 6.3%, a 10% wage increase is associated with a 1.6% increase in the probability of job displacement through firm closing.

The evidence of a positive relationship between reservation wages and failure rates is consistent with the idea of higher entry-level wages due to the existence of compensating differentials for the *ex ante* risk of displacement, which may accelerate the closure process in the short-run. Alternatively, it may merely reflect the scarcity of labor.

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 percentage point increase in the proportion of minimum wage earners increases the probability of displacement by 0.029 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 10% increase in the proportion of minimum wage earners increases the probability of displacement through firm closing by 0.60%.

In fact, the possibility of wage concessions is precluded if workers are paid legal minimum wages. 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.

Past sales growth, firm size, age, market share, multi-plant firm, proportion

[20] In both equations the asymptotic t-ratios correspond to the corrected covariance matrix for the two-step estimator using the methodology developed by Murphy and Topel (1985).

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.

The estimates of the coefficients on the 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 slightly 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.

Table 2: Failure Equation - Two-step Probit Results
Full-time Workers (N=266,024)
Dependent variable: displaced=1

Variables	Coefficient	Marginal Effect
Past Sales Growth	-0.327*	-0.049
	(-31.1)	
Firm Size	-0.242*	-0.037
	(-77.2)	
Firm Age		
Age	-0.059*	-0.009
	(-5.3)	
AgeS5	-0.007	-0.001
	(-0.6)	
AgeS10	0.073*	0.011
	(24.6)	
Market Share	-1.436*	-0.217
	(-29.0)	
Multi-plant Firm	-0.066*	-0.010
	(-6.9)	
Proportion of Foreign Capital	-0.206*	-0.031
	(-11.4)	
Sales per Worker	-0.055*	-0.008
	(-13.8)	
Regional Unemployment Rate	0.055*	0.008
	(7.3)	
Monthly Reservation Wage (predicted)	0.063*	0.010
	(3.2)	
$\Phi(W_M)$ (predicted)	0.192*	0.029
	(5.9)	
Constant	0.741*	0.112
	(3.4)	
Log-likelihood	-88628.6	
Chi-squared	33350.4	

Notes: (a) a set of industry, regional and time dummies are included in the specification;
(b) AgeS5=(Age-5) if Age>5, 0 otherwise; AgeS10=(Age-10) if Age>10, 0 otherwise;
(c) asymptotic t-statistics are in parentheses;
(d) * statistically significant at 1%.

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. 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 (i. e. 6.3%). This implies that if the probability of displacement doubles, say from 6.3% to 12.6%, wages decrease by 5.6%, all else being equal.[21] This empirical result indicates that average wages grow less rapidly in plants that will soon close, suggesting that firms' adjustment to negative shocks are partially absorbed into wages.[22]

[21] If $\widehat{W_0}$ is the predicted wage in a firm with an average failure probability of 0.063 and $\widehat{W_1}$ is the predicted wage in a firm with a double probability of failure, then the relative wage differential is calculated as $\ln(\widehat{W_1}/\widehat{W_0}) = [(-0.892) * (0.063)] = -0.056$.

[22] It should be noted that in Portugal nominal wage reductions are forbidden. Periods of high inflation favor, of course, larger downward real wage adjustments. In the period under analysis, inflation rates reached 8.1% in 1993, 6.1% in 1994 and 4.6% in 1995.

Table 3: Wage Equation - Two-step Tobit Results
Full-time Workers (N=266,024)
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	-0.088
	(-0.8)	
Qualification Levels		
Top Executives	0.762*	0.728
	(62.4)	
Intermediary Executives	0.575*	0.549
	(61.2)	
Supervisors	0.445*	0.425
	(58.5)	
Highly Skilled and Skilled Professionals	0.214*	0.204
	(33.7)	
Semi-skilled and Unskilled Professionals	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: (a) a set of industry, regional and time dummies are included in the specification;
(b) asymptotic t-statistics are in parentheses;
(c) * statistically significant at 1%.

5.3.2 Robustness Checks: Alternative Specifications

At this point it should be noted that our main results remain valid regardless of changes in the model specification. In fact, to further evaluate the robustness of our results, namely their sensitivity to changes in specification, our model was reestimated including a detailed set of workers' characteristics in the failure equation following previous studies such as Cooper *et al.* (1994) and Mata and Portugal (2002), who found human capital to be a good predictor of survival. The results reported in column 1 of Table 4 show that including a set of controls for workers' characteristics (such as gender, age, education and tenure) in the failure equation does not affect our previous results. Indeed, this change increases the positive impact of wages on the probability of closing, suggesting that wages may be correlated with workers' characteristics across firms. Moreover, and even though the impact of the proportion of minimum wage earners in the firm is reduced, it remains positive and statistically significant at the conventional levels.[23]

Some other alternative specifications were tested, namely with the introduction, in the wage equation, of firms' characteristics that might constitute an important determinant of wages, such as size and sales per worker. Again, these changes did not alter our main qualitative results (see column 2 of Table 4).[24]

Finally, it should be pointed out that the effect of wages and the proportion of minimum wage earners in the failure equation remains virtually unchanged if the level of wages is measured as the monthly base wage with no correction for tenure effects (see column 3 of Table 4).

In sum, these robustness checks reveal that the relationships between wages (including minimum wages) and the risk of displacement are robust to the inclusion of workers' and firms' characteristics in the failure and wage equation, respectively, i. e., our main conclusions stand regardless to changes in the model specification.

[23] See Table A.1 of Appendix B for the full results of the failure equation.
[24] See Table A.2 of Appendix B for the full results of the wage equation.

Table 4: Robustness Checks - Two-step Results (coefficient estimates)
Full-time Workers (N=266,024)

	Failure Equation			Wage Equation		
	(1)	(2)	(3)	(1)	(2)	(3)
Probability of Displacement (predicted)				-0.933	-0.479	-0.933
				(-75.7)	(-37.0)	(-75.7)
Monthly Reservation Wage (predicted)	0.251	0.063				
	(8.3)	(3.2)				
$\Phi(W_M)$ (predicted)	0.080	0.192	0.181			
	(2.2)	(5.9)	(5.4)			
Monthly Wage (predicted)			0.052			
			(2.6)			

Notes: (i) specification (1) includes a set of human capital variables (gender, education, tenure and its square, age dummies in the failure equation; specification (2) includes firm size and sales per worker in the wage equation; specification (3) uses the monthly wage instead of the monthly reservation wage in the failure equation; (ii) asymptotic t-statistics are in parentheses; (iii) all coefficients are significant at the 1% or 5% level.

6 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 specified and tested using 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 reservation wages raises the probability of displacement through firm closing by 1.6%.

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. Doubling the average risk of displacement depresses wages by around 6%. This robust empirical evidence reinforces the hypothesis that under a bargaining approach 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 (just around 1.3 percentage points) raises the probability of displacement by 0.6%.

APPENDIX A - Minimum Wage Legislation

A mandatory minimum monthly wage was set for the first time in Portugal in 1974, covering workers aged 20 or older and excluding agriculture and domestic servants. Currently, there is a unique legal minimum that applies to all workers. Workers formally classified as apprentices receive just 80% of the full rate. The minimum pay cannot be reduced by means of collective agreements or individual contracts.

The minimum wage is defined as the base monthly wage and is updated annually by the parliament, under government proposal.[25] Decisions on the level of the minimum wage are taken on a discretionary basis, usually taking into account past and predicted inflation and after consulting the social partners.

According to the 1998 annual report of the Bank of Portugal (1999), in 1995, the minimum monthly wage represents around 43% of the average monthly base wage in the private sector. Data for 1995 also indicate that the proportion of workers that received the minimum legal wage or a subminimum was about 13%, although this percentage has steadily declined since 1985.

The coverage of the legal minimum wage is maximum in the furniture industries and in the sector of restaurants and hotels (coverage higher than 20% in 1995). Coverage is also larger in firms employing fewer than 10 employees.[26]

[25] The only exceptions are 1982, when it was not updated, and 1989, when it was updated twice.

[26] Source: *Earnings Survey* - Statistics Department of the Ministery of Employment.

APPENDIX B

Table A.1: Failure Equation - Two-step Probit Results
Full-time Workers (N=266,024)
Dependent variable: displaced=1

Variables	Coefficient	Marginal Effect
Past Sales Growth	-0.322*	-0.048
	(-30.7)	
Firm Size	-0.253*	-0.038
	(-75.8)	
Firm Age		
Age	-0.056*	-0.009
	(-5.0)	
AgeS5	-0.007	-0.001
	(-0.5)	
AgeS10	0.069*	0.010
	(23.1)	
Market Share	-1.386*	-0.208
	(-28.4)	
Multi-plant Firm	-0.066*	-0.010
	(-6.9)	
Proportion of Foreign Capital	-0.248*	-0.037
	(-13.4)	
Sales per Worker	-0.070*	-0.010
	(-15.8)	
Regional Unemployment Rate	0.072*	0.011
	(9.5)	
Female	0.151	0.023
	(15.5)	
Education	-0.016	-0.002
	(-7.2)	
Worker Age		
18-24	-0.058	-0.008
	(-3.1)	
25-34	-0.050	-0.007
	(-3.4)	
35-54	-0.041	-0.006
	(-3.2)	
Tenure/100	-1.759	-0.264
	(-11.3)	
Tenure/100 Squared	4.442	0.668
	(10.0)	

Table A.1 (continued)

Monthly Reservation Wage (predicted)	0.251*	0.038
	(8.3)	
$\Phi(W_M)$ (predicted)	0.080**	0.012
	(2.2)	
Constant	-0.974*	-0.146
	(3.1)	
Log-likelihood	-88432.4	
Chi-squared	33742.8	

Notes: (a) a set of industry, regional and time dummies are included in the specification;
(b) AgeS5=(Age-5) if Age>5, 0 otherwise; AgeS10=(Age-10) if Age>10, 0 otherwise;
(c) asymptotic t-statistics are in parentheses;
(d) * (**) statistically significant at 1% (5%).

Table A.2: Wage Equation - Two-step Tobit Results
Full-time Workers (N=266,024)
Dependent variable: log of real monthly wage

Variables	Coefficient	Marginal Effect
Female	-0.158*	-0.152
	(-100.8)	
Education	0.050*	0.048
	(160.6)	
Age/100	2.643*	2.536
	(52.6)	
Age/100 Squared	-2.499*	-2.397
	(-40.7)	
Tenure/100	0.479*	0.460
	(15.0)	
Tenure/100 Squared	-0.492*	-0.472
	(-5.3)	
Qualification Levels		
Top Executives	0.742*	0.712
	(101.5)	
Intermediary Executives	0.542*	0.520
	(84.6)	
Supervisors	0.421*	0.404
	(77.0)	
Highly Skilled and Skilled Professionals	0.198*	0.190
	(43.5)	
Semi-skilled and Unskilled Professionals	0.075*	0.072
	(16.2)	
Non-defined	0.349*	0.335
	(58.4)	
Regional Unemployment Rate	-0.060*	-0.058
	(-35.9)	
Sales per Worker	0.070*	0.067
	(90.2)	
Firm Size	0.016*	0.016
	(23.8)	
Probability of Displacement (predicted)	-0.479*	-0.459
	(-37.0)	
Constant	9.356*	8.976
	(678.1)	
Log-likelihood	-76453.8	
$\widehat{\sigma}$	0.31	

Notes: (a) a set of industry, regional and time dummies are included in the specification;
(b) asymptotic t-statistics are in parentheses;
(c) * statistically significant at 1%.

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