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DEMAND FOR LABOUR INPUTS AND ADJUSTMENT COSTS: EVIDENCE FROM SPANISH MANUFACTURING FIRMS

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Abstract

This paper examines the structure of the adjustment costs for heterogeneous labour inputs, allowing for asymmetries and for interaction effects in adjustment costs. To do this, an intertemporal model underlying firm's employment decisions is postulated, and the resulting Euler equations for the demands of permanent nonproduction (white collar) and production (blue collar) employees are estimated using a sample of Spanish manufacturing firms. The main results confirm the heterogeneity of adjustment costs for permanent employees, and the existence of significant cross-adjustment effects. This latter result implies that marginal adjustment costs from firing permanent production employees can be reduced if temporary workers are hired at the same time. However, there is not significant evidence of asymmetric adjustment costs in permanent labour inputs.

Keywords: Labour Demand, Heterogeneous Labour, Adjustment Costs, Panel Data.
JEL Classifications: C33,J23,J23

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1. Introduction

Public regulations aimed at enhancing job-security are outstanding in most of Western European countries, and Spain is not an exception to this rule. These regulations seek to reduce the dismissal of workers and fluctuations in employment, and they are mainly effective by changing the costs of adjustment. To understand how these job-security regulations operate it is therefore necessary to explain how these costs affect labour demand and to infer how such regulations modify them. As stressed by Hamermesh and Pfann (1995), knowledge of the structure of adjustment costs is crucial to understand macroeconomic fluctuations in employment.

Most empirical studies [e.g., Nadiri and Rosen (1969), Sargent (1978)] presume that the quasifixity of labour results from increasing costs of adjustment. Nevertheless, the sources of such costs can be very different depending on whether changes in a firm's employment are either positive (hiring costs) or negative (firing costs). Given the different sources of hiring and firing costs, the adjustment costs will in general depend on the sign of the adjustment. In fact, although adjustment costs have been typically assumed to be symmetric, they yield an unsatisfactory description of the costs that firms face when adjusting employment. Empirically, the dynamics of labour demand based on symmetric (quadratic) adjustment costs are in general at variance with the data. This rejection is stronger as the level of disaggregation rises (e.g., from sectoral to firm data). Using data on Dutch manufacturing firms, Pfann and Verspagen (1989) obtain evidence in favour of asymmetric adjustment costs, in which hiring costs exceed firing costs.

Moreover, the assumption of worker homogeneity can be inappropriate if there are differences in the dynamics of employment among labour inputs, and lead to wrong inferences. Intuitively, one would expect that adjustment costs will be higher the higher the skill of workers: training costs will be lower for unskilled labour, since the firm's expenditure on training will be very small. Furthermore, since severance pay depends on the worker's earnings, which, other things equal, will depend on his occupational level, firing costs will be higher the higher the occupational level. Empirical findings by Palm and Pfann (1990 and 1993), using aggregate data from the Netherlands and the UK, and Bresson *et al.* (1991) using firm-level data from France, among others, show that the adjustment speed of unskilled workers is generally higher than that of skilled workers. Consequently, when firms face a shock, they do not necessarily adjust employment uniformly for the different labour inputs.

Recognising labour heterogeneity requires examining how the costs of changing one type of labour affect the dynamics of demand for other types of labour. The lag in adjusting a particular type of labour should be greater than adjustment lags for other labour inputs if either its variable adjustment costs are more convex or they are simply greater and firms do not know the duration of the shock. Additionally, the shock needed to adjust employment will be greater the greater are the fixed costs of adjustment for that type of labour. More generally, stickiness in adjusting one type of labour will spill over into adjustment for other types of labour.

The main purpose of this paper is to evaluate the structure of adjustment costs for labour considering three different labour inputs, allowing for interrelated dynamics among labour inputs,[1] and for costs asymmetries associated with the hiring and firing of workers. To do this, I use a Spanish panel data set of manufacturing firms corresponding to the period 1986-1991. This data set contains annual information for every firm on the number of employees by duration of the labour contract (fixed-term vs. indefinite) and by job (nonproduction or white

[1]Pindyck and Rotemberg (1983) estimate a system of factor demands using US aggregate manufacturing data, but they assume that the effects of changes in one factor on costs of adjusting other factors are zero, so cross effects in their model appear solely through technology.

collar workers vs. production or blue collar workers). We derive and estimate Euler equations for demands of production and nonproduction employees in a standard profit-maximising framework, using an asymmetric adjustment costs representation.

The case of Spain is specially appealing for two reasons. Firstly, regulations underlying Spanish labour market lie on the same job-security principles as most of Western European countries [see Burda (1991)]. Most of these countries have been characterised by the existence of mandatory severance payments, which increase firing costs leading in practice to (quasi) permanent labour contracts. These higher costs reduce fluctuations in employment at the expense of greater lags in employment adjustment, which generates persistence in employment. In addition, as Blanchard *et al.* (1995) remark, the microeconomic aspects of the Spanish labour market, and in particular its labour market institutions and regulations, "make the Spanish market one of the most rigid in the industrialized world". Before 1984, the labour market legislation only allowed for permanent employment contracts, which entailed restricted conditions for layoffs, with sizeable redundancy payments. Since 1984, restrictions on fixed-term or temporary contracts were gradually eliminated. New labour regulations allowed firms to offer workers temporary contracts for jobs that were not temporary in nature,[2] and to dismiss workers with temporary contracts with low redundancy payments (relative to those for permanent workers, that is, workers with indefinite contracts). These reforms entailed a significant increase in the share of temporary employees in total employment[3] whereas strong regulations on

[2]Prior to 1984, fixed-term contracts were allowed just for seasonal jobs, related to agriculture, construction and tourism activities.

[3]After 1986 there started a huge increase in the number of temporary contracts. The share of temporary employment in Spain rose from 10% in the whole economy and 2% in manufacturing in 1983 to 33% in the whole economy and 10% in manufacturing in 1993. Between 1986 and 1990, 80% of the contracts registered at employment offices were temporary. For a complete description of the typology of temporary contracts in Spain and their effects, see Segura *et al.* (1991).

permanent employment were maintained. In previous work, Sanz Gómez (1994) found that permanent production workers have been strongly substituted by temporary workers. The extensive use of temporary contracts in Spain since the mid-80s, and the fact that the maximum duration of a temporary contract was set at three years, has shaped a dualistic labour market, where labour turnover is high for temporary workers, but very low for permanent ones. The Spanish dataset used in this paper allows us to consider differences in adjustment costs and cross-adjustment effects for three different labour inputs: permanent nonproduction workers, permanent production workers and temporary workers.

The rest of this paper is organised as follows. The basic model that we are interested in is presented in section 2. Section 3 summarises the characteristics of the data set and of the sample period for which data is available, and discusses the econometric approach. The estimation results are presented in section 4. Section 5 gathers the main implications of the empirical analysis and concludes.

2. A dynamic model of labour inputs demands

The firm is assumed to maximise the expected discounted value of the stream of current and future real profits. Every period, it chooses inputs of permanent nonproduction or white collar workers (L_1), permanent production or blue collar workers (L_2), and temporary workers (L_3), and uses capital (assumed to be predetermined).[4] Therefore, the problem to the firm can be written as:

[4]This simplifying assumption, which is equivalent to assume that adjustment costs for capital are not interrelated with labour inputs, might be relaxed introducing cross-adjustment terms for capital in the adjustment costs function. We rule out this possibility in order to minimise the number of parameters to estimate.

$$\max_{\{L_t^j\}_{j=1}^{3}} E_t \sum_{s=0}^{\infty} \rho_{t+s} \left(F(L_{t+s}, K_{t+s}) - AC(L_{t+s}, L_{t+s-1}) - \sum_{j=1}^{3} W_{t+s}^j L_{t+s}^j \right) \qquad (1)$$

where $E_t[.]=E[.\,|\Omega_t]$, with Ω_t being the information set available to the firm when choosing labour inputs at time t; F(.) is the production function, which depends on the vector of labour inputs, $L_t=(L_t^1,L_t^2,L_t^3)'$, and the capital stock K_t. The function AC(.) represents external adjustment costs measured in output units. Finally, W_t^j is the real wage paid to labour input j, L_t^j. The adjustment costs function AC(.) is defined in terms of the growth rates of the number of workers, that is, $AC(L_{t+s},L_{t+s-1})=AC(\Delta \ln L_{t+s})$. Whereas adjustment costs can be very important for permanent workers, they are assumed to be negligible for temporary workers.

The first-order conditions (Euler equations) corresponding to this maximisation problem can be written as:

$$E_t\left[\frac{\partial F_t}{\partial L_t^j} - W_t^j - \frac{\partial AC(L_t,L_{t-1})}{\partial L_t^j} - \rho_{t+1}\frac{\partial AC(L_{t+1},L_t)}{\partial L_t^j}\right] = 0, \quad (j = 1,2) \qquad (2)$$

To get explicit forms for the Euler equations, it is necessary to take parameterisations of the technology and the adjustment costs function. For the technology, we take a parsimonious and homogeneous representation that allows for non-constant elasticities of substitution:

$$Y_t = A_t K_t^{\alpha} \prod_j \left(N_t^j\right)^{\beta_j} \left(\Sigma_j N_t^j\right)^{\beta_0}, \qquad (3)$$

where N_t^j denotes labour input j in annual units.[5] Therefore, for each labour input, we have

[5]That is, whereas for permanent labour inputs (j=1,2), $N_t^j=L_t^j$, for the temporary labour input $N_t^3 = L_t^3 \times$(Average number of weeks worked along the year)/52.

$$\frac{\partial F_t}{\partial L_t^j} = \frac{\partial F_t}{\partial N_t^j}\frac{dN_t^j}{dL_t^j} = \left[\beta_j\left(\frac{Y_t}{N_t^j}\right) + \beta_0\left(\frac{Y_t}{\Sigma_k N_t^k}\right)\right]\frac{dN_t^j}{dL_t^j} \tag{4}$$

Adjustment costs for permanent labour inputs allows for asymmetries between firing and hiring costs, that is, the cost of a positive change is allowed to differ from the cost of a negative change of the same size. Furthermore, we allow for cross-adjustment effects amongst different labour inputs. In fact, although it is assumed that changes in temporary workers (L_t^3) do not entail adjustment costs, they may affect adjustment costs associated with permanent workers. We assume that labour adjustment costs can be written in terms of the growth rates of labour inputs, and postulate two alternative empirical specifications. The first one is a third degree polynomial on the growth rates of labour inputs:

$$\begin{aligned} AC(\Delta \ln L_t) = {} & \frac{1}{2}\sum_{m=1}^{2} \gamma_{mm} (\Delta \ln L_t^m)^2 + \frac{1}{3}\sum_{m=1}^{2} \delta_m (\Delta \ln L_t^m)^3, \\ & + \gamma_{12}(\Delta \ln L_t^1)(\Delta \ln L_t^2) + \gamma_{13}(\Delta \ln L_t^1)(\Delta \ln L_t^3) + \gamma_{23}(\Delta \ln L_t^2)(\Delta \ln L_t^3) \end{aligned} \tag{5.a}$$

where asymmetry between hiring and firing costs arises whenever $\delta_j \neq 0$: hiring costs will be higher (resp. lower) than firing costs if $\delta_j > 0$ (resp. $\delta_j < 0$). The coefficients γ_{jk} capture possible interactions among adjustments in different labour inputs. Note that this specification allows for the marginal cost of adjusting one labour input to be reduced if another labour input is changed accordingly. For example, if $\gamma_{jk} > 0$ (resp. $\gamma_{jk} < 0$) and $\Delta L_t^j < 0$, adjustment costs will be reduced if $\Delta L_t^k > 0$ (resp. $\Delta L_t^k > 0$).

The parameters associated with the cubic terms in this specification, however, can entail identification problems if the variability in the growth rates of labour inputs is small. For this reason, we will also use an alternative quadratic specification, which differs from the conventional quadratic specification by the fact that, as in (5.a), interactions are introduced, and coefficients associated with quadratic terms are allowed to be different depending on the sign of adjustment:

$$AC(\Delta \ln L_t) = \frac{1}{2}\sum_{m=1}^{2} \gamma_{mm}^{P} (\Delta \ln L_t^m)^2 I_t^m + \frac{1}{2}\sum_{m=1}^{2} \gamma_{mm}^{N} (\Delta \ln L_t^m)^2 (1 - I_t^m) \\ + \gamma_{12}(\Delta \ln L_t^1)(\Delta \ln L_t^2) + \gamma_{13}(\Delta \ln L_t^1)(\Delta \ln L_t^3) + \gamma_{23}(\Delta \ln L_t^2)(\Delta \ln L_t^3) \tag{5.b}$$

where I_t^m equals one if $\Delta L_t^m > 0$, and zero otherwise. Differences between the coefficients γ_{jj}^P and γ_{jj}^N capture asymmetry between hiring and firing costs, so that if $\gamma_{jj}^P > \gamma_{jj}^N$ (resp. $\gamma_{jj}^P < \gamma_{jj}^N$) hiring costs are higher (resp. lower) than firing costs.[6]

For each labour input, we will have:

$$\frac{\partial AC(\Delta \ln L_t)}{\partial L_t^j} = \frac{1}{L_t^j}\left[\frac{\partial AC(\Delta \ln L_t)}{\partial \Delta \ln L_t^j}\right], \tag{6}$$

and the Euler equation for the jth labour input can be written as:

$$E_t\left[\left(\frac{\partial F_t}{\partial L_t^j}\right) - W_t^j - \frac{1}{L_t^j}\frac{\partial AC(\Delta \ln L_t)}{\partial \Delta \ln L_t^j} + \rho_{t+1}\frac{1}{L_t^j}\frac{\partial AC(\Delta \ln L_{t+1})}{\partial \Delta \ln L_{t+1}^j}\right] = 0 \quad (j = 1,2). \tag{7}$$

Even though the Euler equations include unobserved expectations of forward variables, we can substitute them by their actual values and add an expectational error. Under rational expectations, and in the absence of measurement errors and macroeconomic shocks, this expectational error ε_{t+1}^j satisfies the orthogonality condition $E[\varepsilon_{t+1}^j | \Omega_t] = 0$. However, while

[6]Whereas the main source of asymmetry for each j-th input comes through either δ_j in (5.a) or γ_{jj}^P and γ_{jj}^N in (5.b), the coefficients γ_{jk} only have a marginal impact on the asymmetry between hiring and firing costs; their main effect is on the convexity curvature of the adjustment costs function.

expectations of forward variables will be a function of variables in the information set Ω_t (and thus orthogonal to the error term), actual values of variables dated t+1 will no longer be orthogonal to the error term. Therefore, OLS estimates will be inconsistent and an instrumental variable approach will be needed in estimation, where in principle any variable included in the information set will be a valid instrument.

Moreover, the system containing the Euler equations for both nonproduction and production workers incorporates cross-equation restrictions in technology and adjustment costs. We will perform joint estimation of the system using the Generalised Method of Moments.

3. The data and econometric issues

The main data set is a balanced panel of 1,080 manufacturing firms recorded in the database of the *Central de Balances del Banco de España* (*Central Balance Sheet Office*, after this, CBBE) during the period 1986-1991. Although this database contains information on the balance sheets and other complementary information for a large number of manufacturing companies since 1982, dissaggregated data on employment is reported only since 1986. We have thus selected all those firms who remained in the sample along the whole period 1986-1991, and satisfied several coherency conditions, which are described in the Data Appendix. Data on three categories of employment are available: permanent employees, which are broken down by occupation into nonproduction or white collar workers and production or blue collar employees, and temporary employees. Unfortunately, no breakdown by occupation exists for temporary employees. Finally, another limitation of the data is that there is no data available on firings and hirings, so we can only measure net changes through the change in the stock of labour inputs but we cannot measure gross changes in labour inputs.[7] Consequently, all the dynamics that can be captured when estimating the model will be based on net changes in employment. The distribution of firms by size and by industry is reported in Table 1.

Even though the CBBE data includes information on the firm's average wage rate for its labour force (firm's labour costs/number of employees), the firm's wage rate for each labour input is not reported. Complementary data on wages is obtained from the *Encuesta de Salarios* (*Wage Survey*, source: National Statistics; ES after this) and from *Distribución Salarial en España* (*Wage Distribution in Spain*, source: National Statistics, DS after this). The ES survey provides industry-level information about average wages for production and nonproduction employees per year, irrespective of contract duration. In order to distinguish the wage rates between temporary and permanent employees, we use the DS survey. Unfortunately, the DS survey reports this information at industry level just for 1988, so we will not be able to capture any time variation of relative wages between temporary and permanent employees.

Since we only observe the wage rate for each labour input by industry, we will assume that the wage rate for each labour input relative to the remaining labour inputs is the same for firms in the same industry. Let W_{it}^{j}, W_{it}^{k} be the average wage rates of the ith firm in period t for the labour inputs j,k (j,k=1,2,3) respectively. We can relate these two wage rates in the form:

$$W_{it}^{j} = \mu_{it}^{j,k} W_{it}^{k}, \tag{8}$$

where $\mu_{it}^{j,k}$ is the margin of the wage rate for labour input j over the wage rate for labour input k. Given that at the firm level we only observe the total wage bill and the number of the three types of workers, to achieve identification we will assume that the margins $\mu_{it}^{j,k}$ are equal for

[7]We believe that this problem is more acute the higher the level of aggregation in employment, so hopefully disaggregation of employees by occupation and by type of contract will reduce the difference between net and gross changes.

firms in the same industry. We will calculate these margins from information on the average wage rates per labour types contained in the ES and the DS surveys.[8]

The assumptions needed to construct the wage rates for different labour inputs imply that if a firm pays a wage rate above the industry wage rate to certain type of worker, it pays wages above the industry wage rate to all types of workers. This is partly consistent with Krueger and Summers (1988) for the US and, particularly, with Andrés and García (1991), for Spain, where firms that pay wages above the average in some category tend to pay wages above the average in all categories.

Value added in Spanish manufacturing registered an annual average growth rate of 3.9% during the period 1986-1990. Employment in manufacturing grew accordingly at an average annual rate of 2.7%. In the former expansive period (1966-1974), an annual growth rate of 9.1% in manufacturing value added led to a 3.4% employment growth.[9] This greater elasticity of employment to GDP growth in the eighties is partly explained by the greater flexibility of the Spanish labour market. As Bentolila and Dolado (1994) stressed, the introduction of temporary contracts has contributed to reduce the persistence in the level of employment. The share of temporary employment in Spanish manufacturing has risen monotonically along the period 1986-1990. Table 2 shows the evolution over time of the main variables related to firms' activity for our sample. The most striking fact from Table 2 is that the evolution of different labour types has been very dissimilar, which confirms that assuming homogeneous labour would hide differences in employment dynamics for the different labour inputs. Whereas the number and

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[8]Obviously, whereas the wage margin of labour input j relative to labour input k will be constant across firms in the same industry, the wage margin of a given labour input with respect to the average wage rate (total labour cost/total employment) will in general be different across firms, reflecting the different occupational structure of employment across firms.

[9]This discussion about employment refers to employees and excludes self-employed workers.

the share in total employment of permanent employees decreases along the period, temporary employment experienced a sharp growth from 1987 to 1990.[10] Such period corresponds to the booming years, with high growth rates in real output, which contrasts with the evolution of permanent employment along the same years. The reduction in permanent employment is mainly due to a large reduction in permanent production employment: its share in total employment falls monotonically from 62.3 per cent in 1986 to 55.8 per cent in 1991.

Tables 3 and 4 report, for each labour input, the sample frequencies from 1987 to 1991 of movements by year and by size, respectively. Examining these tables, the following conclusions can be drawn. First, while the proportion of observations not adjusting temporary employment is very small, we found a significant proportion of firms not adjusting permanent employment. Moreover, adjustments are much more infrequent for nonproduction workers. This keeps consistency with higher levels of firm-specific human capital investment for this type of workers. Second, for any labour input, the larger the firm is, the higher the probability of adjustment. This evidence can be due either to the existence of fixed costs of adjustment or to the existence of indivisibilities in labour inputs, which are more important the lower the firm's size.[11]

The finding that many firms do not adjust employment every year is inconsistent with a differentiable specification for adjustment costs, because there should not be any mass point for $\Delta \ln L_{it}^{j}$. If observations with $\Delta \ln L_{it}^{j}=0$ are due to indivisibilities, the Euler equations would still be valid for observations for which adjustment is done. In such a case, the Euler equations

[10]Even though the employment trend for our sample matches that for total manufacturing until 1991, the growth rates for our sample are significantly lower than the rate for total manufacturing employment in this period.

[11]In the basis of informal evidence, it appears that smaller firms make fewer adjustments in the number of employees but in turn they exploit more frequently the possibility of overtime hours. Unfortunately, we only have data on number of employees, but not on hours effectively worked.

can be estimated using observations for which adjustment in both permanent labour inputs in two consecutive periods is done. Since sample selection depends on the variable of interest, endogeneity of selection must be accounted for. For the full sample, the error term in the Euler equation satisfies $E_t[\varepsilon_{i,t+1}^j]=E[\varepsilon_{i,t+1}^j|\Omega_t]=0$, where Ω_t is the information set at period t. Let $D_{it}=\mathbb{I}(\Delta L_{it}^1\Delta L_{it}^2\neq 0)$, where $\mathbb{I}(\cdot)$ is the indicator function, and ΔL_{it}^1 and ΔL_{it}^2, are the changes in permanent nonproduction and production labour, respectively: for estimation, we will use those observations satisfying $D_{i,t+1}D_{it}=1$. We can write the probability of $D_{i,t+1}D_{it}=1$ as $Pr[\pi' Z_{i,t+1}+\upsilon_{i,t+1}>0]$, where Z_{it} consists on variables included in the information set at period t. Thus, for equation j we will have that $E_t[\varepsilon_{i,t+1}^j|D_{i,t+1}D_{it}=1]=\sigma_{t+1}^j\lambda_{i,t+1}\neq 0$, where σ_{t+1}^j is the covariance between $\varepsilon_{i,t+1}^j$ and $\upsilon_{i,t+1}$ (normalised by the variance of $\upsilon_{i,t+1}$), and $\lambda_{i,t+1}$ is a function of the Z's which, if $\upsilon_{i,t+1}$ is normally distributed, is the inverse of the Mills' ratio [see Amemiya (1984)]. The error term has no longer zero mean, yet it is possible to reformulate the model in terms of $u_{i,t+1}^j=\varepsilon_{i,t+1}^j-\sigma_{t+1}^j\lambda_{i,t+1}$, so that

$$E_t[u_{i,t+1}^j|D_{i,t+1}D_{it}=1] = 0 \tag{9}$$

Euler equations will be estimated as a joint system by the Generalised Method of Moments (GMM). The Euler equation for labour input j can be written as

$$E_t[h^j(x_{it},x_{i,t+1},\theta)] = E[h^j(x_{it},x_{i,t+1},\theta)|\Omega_{it}] = 0, \quad j=1,2 \tag{10}$$

where $h^j(x_{it},x_{i,t+1},\theta)=u_{i,t+1}^j$. Defining $h(x_{it},x_{i,t+1},\theta)=[h^1(.),h^2(.)]'$, the system of Euler equations for both permanent labour inputs can be written as

$$E[h(x_{it},x_{i,t+1},\theta)|\Omega_{it}] = 0 \tag{11}$$

Substituting the expected values of variables dated t+1, we can write the Euler equations in terms of observables as

$$h(x_{it},x_{i,t+1},\theta) = u_{i,t+1} \tag{12}$$

where $u_{i,t+1}=[u_{i,t+1}^{1},u_{i,t+1}^{2}]'$ denotes the vector of expectational errors in both Euler equations, such that $E[u_{i,t+1}|\Omega_{it}] = E[\varepsilon_{i,t+1}-\sigma_{t+1}\lambda_{i,t+1}|\Omega_{it},D_{i,t+1}D_{it}=1]=0$, with $\sigma_{t+1} = [\sigma_{t+1}^{1},\sigma_{t+1}^{2}]'$. The error term will be orthogonal to all variables included in the conditioning set at t, but not to variables dated t+1; instrumental variable estimation is thus needed. Every $z_{kit}\in\Omega_{it}$ will be a valid instrument, for it will fulfil the orthogonality condition $E[\varepsilon_{i,t+1}z_{kit}]=0$. Such orthogonality conditions between the error term and the instruments yield a vector of moment restrictions for every firm i, which we denote as $\psi_i(x_i,\theta)=[\psi_{i1}',\psi_{i2}',...,\psi_{iT}']'$, where $\psi_{it}(\theta)=h(x_{it},x_{i,t+1},\theta)Z_{it}$ and $Z_{it}=[z_{1t},z_{2t},...,z_{Kt}]$. GMM procedures exploit the sample analogues of such moment restrictions, where $\hat{\theta}_{GMM}$ is the estimator that minimises the quadratic form:

$$\sum_i \psi_i(x_i,\theta)' A_N \sum_i \psi_i(x_i,\theta) \tag{13}$$

where A_N is a weighting matrix. Under some regularity conditions, the GMM estimator $\hat{\theta}_{GMM}$ is consistent for arbitrary choices of the weighting matrix A_N. Nevertheless, A_N can be chosen optimally to obtain an (asymptotically) efficient GMM estimator. This optimal choice of A_N is given by V_N^{-1}, where V_N is a consistent estimate of the covariance matrix of the moment restrictions.[12] The cross-equation restrictions in the system of Euler equations induce non-

[12]The asymptotically optimal weighting matrix is V^{-1}, where $V=E[\psi_i(x_i,\theta)\psi_i(x_i,\theta)']$. A consistent estimate of V is its sample analogue, based on a consistent estimate of θ, that is, $\hat{V} = \frac{1}{N}\sum_i\left[\Psi_i(x_i,\hat{\theta})\Psi_i(x_i,\hat{\theta})'\right]$. Usually, a consistent first step estimate is obtained by setting A_N to some

linearities, so that θ must be obtained by numerical optimisation, see Ogaki (1993). Estimation was performed using a program written in GAUSS language and the optimisation algorithm of Broyden, Fletcher, Goldfarb and Shanno included in the GAUSS application module OPTMUM. We will compute two-step GMM estimates, that take the weighting matrix $W_N(\theta)$ based on the one-step GMM estimates (that in turn use the identity matrix as the weighting matrix). The fact that λ_{it} is replaced by a sample estimate in the econometric specification implies that the conventional standard errors will be, strictly speaking, inconsistent. However, obtaining consistent standard errors in this framework is a nontrivial task that is beyond the scope of this paper, and therefore we will not consider this problem.

4. Estimation results

We estimate the model for both permanent labour inputs, nonproduction and production workers, but we did not estimate the Euler equation for temporary employees; this input enters contemporaneously the Euler equations for permanent employment and is treated as endogenous. Given that estimation is done for observations for which adjustments occur in both types of permanent labour in the current and the previous period, it is necessary to control for the endogeneity of selection. As discussed in the former section, under endogenous sample selection the error term will no longer have zero mean, that is $E_t[\varepsilon_{i,t+1}^j | D_{i,t+1}D_{it}=1]=\sigma_{t+1}^j\lambda_{i,t+1}$. We will thus estimate a Probit model for the probability that non-zero adjustments in both permanent labour inputs occur, and calculate $\lambda_{i,t+1}$ as the inverse of the Mill's ratio, see Amemiya (1984). Of course, to ensure that the inclusion of $\hat{\lambda}_{i,t+1}$ does not introduce endogeneity, Probit estimation

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known value, and then A_N is obtained by setting $A_N = \hat{V}^{-1}$ for the two step estimate. See Arellano and Bond (1991) or Ogaki (1993).

is carried out year by year, using variables that are valid instruments in the Euler equations. In addition, given that generalised heteroscedasticity is allowed, the coefficients on $\hat{\lambda}_{i,t+1}$ are allowed to be time-varying. Estimates of the reduced-form Probit equations from 1988 to 1991 are reported in Table 5.

As described above, the wage measure for the labour input jth in the firm i is computed using firm-level information on the average wage and industry-level information on relative wages for nonproduction and production employees. Therefore, the wage measure W_{it}^{j} is expected to be measured with error, differing from the true wage W_{it}^{j*} by a multiplicative error term. It seems plausible to assume that such error term will contain a highly persistent component. For instance, for a firm paying an actual relative wage for the jth labour input that is higher than the corresponding industry-level relative wage, the measured relative wage (based on industry-level information) will be lower than the true relative wage, so that there is a downward measurement error. In such a case, the relative wage for the jth labour input in such firm will be more likely to remain above the industry-level relative wage in subsequent periods, so that presumably there will be a downward measurement error in the subsequent periods. Therefore, we postulate the following relationship between the natural logarithm of the true real wage and the natural logarithm of the observed real wage:

$$\omega_{it}^{j} = \omega_{it}^{j*} + \eta_{i}^{j} + \zeta_{it}^{j} \qquad (14)$$

where the structure of the measurement error in wages is characterised by a time-invariant, firm-specific, measurement error component, and an additional uncorrelated component ζ_{it}^{j} reflecting further differences between the measured logarithm of the wage and the logarithm of the true wage. Notice that some assumption about the measurement error structure, like the one we make for the logarithm of wages, is necessary for model identification.

The model is estimated in first-differences to account for this source (and other possible sources) of firm-specific fixed effects. To control for aggregate shocks affecting all firms equally, we include time dummies in both Euler equations, and allow the coefficients on the time dummies to differ across labour inputs. Finally, we control for the degree of utilisation of production factors using 2-digit industry-level data on capacity utilisation. We compute the firms' real discount rate using a measure of the long term nominal interest rate deflated by the corresponding industry-level price indices. See the Data Appendix for a complete description of the variables.

Under measurement errors in wages, and even assuming that these measurement errors are serially uncorrelated, only the values of predetermined values dated t-2 and earlier are valid instruments.The instrument set for the Euler equation for input j contains values of changes in the three labour inputs lagged two and three periods, lagged values of average real productivities of labour inputs, and the real wage for input j lagged two periods. These variables are arranged to enter as they do in the levels specification of the Euler equation, which significantly improves the precision of the estimates. For the adjustment costs representation (5.b), it was found important the inclusion in the instrument set of dummy variables describing whether adjustments in labour inputs were positive or negative interacted with changes in their corresponding labour inputs.

One important issue is that although the parameters of the set of Euler equations are theoretically identified, yet it is necessary to account for sufficient variability in the data to capture the effects of positive and negative adjustments in labour inputs. Table 6 suggests that there exist sufficient frequencies of cross adjustments of different signs among the different labour inputs to guarantee this.

Two-step estimates of the set of Euler equations given by (7) and the adjustment costs parameterisation (5.a) are reported in the first column of Table 7. Parameters associated with quadratic terms are positive for both nonproduction workers (γ_{11}) and production workers (γ_{22}). We also find positive and significant coefficients for the cross-adjustment term between permanent nonproduction and permanent production workers (γ_{12}) as well as for the cross-adjustment effect between production workers and temporary workers (γ_{13}). The implication is that the marginal costs of firing permanent production employees, for example, can be reduced if either permanent nonproduction or temporary workers are hired at the same time. Even though the sign of the asymmetry coefficients δ_j is negative (suggesting that firing costs exceed hiring costs), they are clearly non-significant, which can be due to the high correlation between the quadratic and the cubic terms, making parameter estimates imprecise.

This sort of evidence is also found for the Euler equations corresponding to the adjustment costs specification (5.b), whose estimates are reported in the last column of Table 7. The parameters associated with the quadratic term when hiring occurs are positive for nonproduction and production employees (γ_{11}^P and γ_{22}^P), although non significant. Furthermore, hiring costs are higher for nonproduction employees, what is consistent with the need of firm-specific human capital investment the higher the occupational level of the worker. The coefficients for the quadratic term when firing is done are also positive for both types of permanent labour, which would ensure convexity of the adjustment costs function in the absence of interactions. Even though for both labour inputs, γ_{jj}^N is higher than γ_{jj}^P, which would imply that firing costs are higher than firing costs, the low significance of the coefficients does not yield strong evidence on this. From the J test, we can see that the probability above which the overidentifying restrictions would be rejected is about ten percent for both specifications.[13]

Interestingly, values of the cross-adjustments coefficients γ_{jk} imply the previous qualitative results, implying that when reducing labour input of type j, significant reductions in marginal adjustment costs are possible if the amount of another labour input is increased. Considering the two alternative specifications, we only found significant differences in the value of the cross adjustment effect between permanent labour inputs (γ_{12}). Our results thus show that interrelations among labour inputs are important for the dynamics of demand of labour inputs, for they are affected by changes in the costs of other inputs. Since coefficients for cross-adjustments terms are positive, if employees of a given type are fired, the incurred marginal cost is reduced if workers of a different type are hired at the same time. In our context, it is clear that the generalisation of temporary contracts has contributed to lessen the cost of dismissing permanent employees (especially, production employees). One striking result concerns the high value of γ_{12} with respect to the remaining interaction terms, which is partly surprising given the heterogeneity between production and nonproduction employees. This coefficient can be possibly capturing, in addition to cross-adjustment effects, the effect of a change towards technologies of production less intensive in production workers. The increase both in net fixed-capital investment and in the share of permanent nonproduction employment, as shown in Table 2, favours this explanation.

The least satisfactory results concern the technology coefficients, whose values entail implausibly low marginal productivities for both permanent labour inputs. There are two possible explanations to this problem. The first one is that the correlation between the variables

[13]Although the J test is usually used to test the validity of the instrument set, it is a general specification test, that gives evidence on the validity of the model. However, rejection of the overidentifying restrictions says nothing about the source of model misspecification.

associated with marginal adjustment costs and the average productivities of labour inputs is high. However, this problem is not very acute in our case, because the different functional forms for marginal adjustment costs and technology ensures that the sample correlation between such variables is not too high. The second one is that the perfect competition assumption is inappropriate and the technological coefficients are downward biased: under a simple model of imperfect competition, e.g., monopolistic competition, the β coefficients would capture $\beta^*(1-\varepsilon)$, where β^* and ε are the true technological coefficient and the firm's elasticity of demand for output, respectively. However, lack of data on output prices at the individual firm level would make difficult to identify ε. This problem was also apparent with a Cobb-Douglas technology. Alternative specifications for technology (translogarithmic and quadratic, among others) and the introduction of some forms of imperfect competition were tried. Nevertheless, these alternative specifications introduced additional parameters and additional cross-equation restrictions, worsening the convergence of the algorithm and the precision of the estimates.

As Bresson *et al.* (1991) stress, one must not believe that estimates of the Euler equations give the global adjustment costs function. Such estimates, which are very dependent on the sample behaviour of employment, give only an indication of the local shape of this function. In particular, as Table 2 shows, the sample period (1987-1991) is characterised by a huge increase in the number of temporary employees together with a fall in permanent production employees.

To end up, evidence on asymmetry through quadratic terms is not conclusive. In fact, when testing symmetry (δ_j=0, j=1,2) in specification (5.a), the value of the statistic (asymptotically distributed as a χ^2_2) is 0.44, so the symmetric specification cannot be rejected. What seems to be clear is that adjustment costs differ for both types of permanent workers, and that cross adjustment terms (especially those linked to production employees) are clearly significant.

5. Conclusions

In this paper we have derived and estimated interrelated Euler equations for demand of permanent labour inputs, namely production and nonproduction workers, in a dynamic optimisation framework under rational expectations. To do this, the capital stock was taken as predetermined and temporary labour was included as a separate labour input to consider interrelations with both types of permanent labour. The specification we have used allows for asymmetries between hiring and firing costs and for cross-adjustments effects among different labour inputs. The alternative adjustment costs functions were formulated in terms of relative changes in employment to take into account the relative sizes of firms. The econometric analysis was performed using a panel of 1080 Spanish manufacturing firms.

The main conclusions that can be drawn from the estimations are as follows. First, there is evidence on heterogeneity in adjustment costs between permanent labour inputs. Second, cross-adjustment effects among different labour inputs are positive, thus implying that if the firm reduces its level for a given labour input, costs of adjustment can be reduced at the margin if the firm increases the level of a different labour input at the same time. These cross-adjustment effects are specially important for permanent production workers. The interaction coefficient with permanent nonproduction workers and temporary workers is positive and significant. From this result, in a context of a reduction in the number of permanent production employees, the induced costs of such reduction can be lowered if permanent production labour is substituted by temporary labour. The interaction coefficient between temporary workers and permanent nonproduction workers, however, is small and non significant, which is consistent with the fact that temporary employment is hardly a close substitute of nonproduction employment. Therefore, reductions in adjustment costs induced by the massive introduction of temporary contracts have not been possibly so important as in the production workers case. Third, evidence on asymmetry between firing and hiring costs is not clear-cut: in fact, symmetry is not rejected by the data. Finally, adjustment costs for nonproduction workers appear to be higher than adjustment costs for production workers. Intuitively, this is a sensible result, because of the higher firm-specific human capital associated with nonproduction or white collar workers.

However, our results need to be qualified for a number of reasons. Mainly, most of the limitations of this study are intrinsically linked to the limitations of the data. First, as asserted by Hamermesh (1992 and 1993) and Hamermesh and Pfann (1995), employment plans are likely to be revised more frequently than once a year. Use of data at annual frequencies can lead to wrong inferences on the underlying structure of adjustment costs;[14] empirically, quarterly data seem to be more adequate. In fact, the frequency at which demand for labour inputs is revised will be higher the higher the flexibility of the contract. Therefore, the incidence of this problem will be more acute in the case of temporary workers than in the case of permanent workers.

Second, since there is no available data on hirings and firings but only on the level of labour inputs, it is only possible to identify adjustment costs associated with net changes in the level of labour inputs. Certainly, costs associated with gross changes in labour inputs may be important even if there is no change in the level of labour inputs. Another data limitation is that there is no information on hours worked, so it is implicitly assumed that employees and hours move together. The existence of flexibility in hours allows firms to change hours when it is not

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[14]Hamermesh (1992) suggest that use of temporally aggregated data can only offer smooth approximations to the underlying structure of adjustment costs.

profitable to alter employment. This problem, pointed by Hamermesh (1993), does not seem so important in the case of European labour markets, were regulations on working hours are very rigid.[15] Particularly, in the case of Spain, dispersion in weekly working hours is not very high.

Third, whereas the empirical analysis has taken capital stock as predetermined, it is plausible that the decisions of investment and labour demand were interrelated. In such a case, the adjustment costs function could be augmented to include cross-adjustments of labour and capital inputs. However, the generalisation towards a more realistic model should pay the price of a less parsimonious model and other potential misspecification problems related to assumptions on the timing of investment decisions and on the moment when newly hired capital becomes productive.

Finally, we believe that the main limitation concerns the small number of cross sections available to estimate the model. This circumscribes the validity of the results, because estimations of the parameters may strongly depend on the aggregate phenomena that occurred in the sample period. Only the availability of data for additional periods can clarify this question.

[15] In the United States, the dispersion of hours worked is very high, so hours adjustment is effectively a mechanism that enhances employers' flexibility to adjust their production to market conditions.

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DATA APPENDIX

Construction of the data set

The sample consists on a balanced panel of 1,080 non-energy manufacturing firms, with a public share lower than 50 percent and with positive employment and labour costs, reported to the Bank of Spain's Central Balance Sheet Office from 1986 to 1991. To obtain this final sample, we applied sequentially the following filters:

(1) Filters needed to construct the market value of the capital stock:

(a) Book value of capital stock, total accumulated depreciation and annual depreciation of the capital stock must be positive.

(b) The average life of capital must lie between percentiles 1st and 99th, and the average age of the capital stock must be lower than the 80% of its average life.

(e) The absolute growth in the book value of the capital stock cannot be greater than 300%.

(2) Filters related with the performance of the firm:

(a) Sales, gross output and total labour costs must be positive.

(b) Accounting equity must be positive.

(c) The firm cannot change from one industry to another.

(d) Both permanent non-production employment and permanent production employment must be positive.

Variable construction

Employment

Number of employees is dissagregated in *permanent nonproduction, permanent production* and *temporary* employees. To maintain measurement consistency, number of temporary employees is calculated in annual terms by multiplying the number of temporary employees along the year times the average number of weeks worked by temporary employees and divided by 52.

Real wages

The measure of the firm's annual average labour costs per employee W_{it} is computed as the ratio of Total wages and salaries to Total number of employees. This measure was deflated using Retail Price Indices for each of the subsectors of manufacturing industry. (Source: Spain's Institute of National Statistics, hereinafter INE). Computation of average wages per type of worker is done using information on wages of non-production and production employees at sectoral level from *Encuesta de Salarios* and on wages of permanent and temporary employees at sectoral level from *Distribución de Salarios* (Source: INE).

The wage for temporary employees is computed as $W^T_{it}=W_{it}(L_{it}^T+L_{it}^P)/(L_{it}^T+L_{it}^P\mu_{it}^{P,T})$, where, for period t, L_{it}^T L_{it}^P are the average annual number of temporary employees and the number of permanent employees in the firm, respectively, and $\mu_{it}^{P,T}$ is the wage margin of permanent employees with respect to temporary employees (obtained at the sectoral level from *Distribución de Salarios*). The wage of permanent employees is thus $W^P_{it}=\mu_{it}^{P,T}W^T_{it}$. The wage for permanent production or blue collar employees can be computed as $W_{it}^{Pb}=(W^P_{it}L_{it}^P)/(L_{it}^{Pb}+L_{it}^{Pw}\mu_{it}^{b,w})$, where, for period t, L_{it}^{Pb} and L_{it}^{Pw} are the number of permanent production (blue collar) employees and permanent nonproduction (white collar) employees, respectively, and $\mu_{it}^{b,w}$ is the wage margin of nonproduction employees with respect to production employees (obtained at the sectoral level from *Encuesta de Salarios*). Finally, the wage of permanent white collar employees is computed as $W_{it}^{Pw}=\mu_{it}^{b,w}W_{it}^{Pb}$.

Output

Gross output at retail prices is calculated as total sales, plus the change in finished product inventories and other income from the production process, minus taxes derived on the production (net of subsidies).

Interest rates

To compute the discount rate, we use as long-term interest rate that on the electricity company bonds. (Source: Bank of Spain). The real rate of return is computed deflating the nominal rate of return by the corresponding Retail Price Index at the 2-digit industry classification (Source: INE).

Table 1
Distribution of firms by industry and by size

		Small	*Medium 1*	*Medium 2*	*Large*	*Total*
Iron, steel and metal (22)	Absolute freq.	1	4	3	2	10
	% in the industry	10.00	40.00	30.00	20.00	100.00
	% in size category	0.66	1.07	1.03	0.76	0.93
Building materials, glass and ceramics (24)	Absolute freq.	12	38	21	17	88
	% in the industry	13.64	43.18	23.86	19.32	100.00
	% in size category	7.89	10.16	7.22	6.46	8.15
Chemicals (25)	Absolute freq.	15	42	39	54	150
	% in the industry	10.00	28.00	26.00	36.00	100.00
	% in size category	9.87	11.23	13.40	20.53	13.89
Non-ferrous metal basic industries (31)	Absolute freq.	15	55	22	16	108
	% in the industry	13.89	50.93	20.37	14.81	100.00
	% in size category	9.87	14.71	7.56	6.08	10.00
Basic Machinery (32)	Absolute freq.	13	27	22	13	75
	% in the industry	17.33	36.00	29.33	17.33	100.00
	% in size category	8.55	7.22	7.56	4.94	6.94
Office Machinery (33)	Absolute freq.	0	0	0	1	1
	% in the industry	0.00	0.00	0.00	100.00	100.00
	% in size category	0.00	0.00	0.00	0.38	0.09
Electric materials (34)	Absolute freq.	3	14	15	23	55
	% in the industry	5.45	25.45	27.27	41.82	100.00
	% in size category	1.97	3.74	5.15	8.75	5.09
Electronic (35)	Absolute freq.	1	2	7	6	16
	% in the industry	6.25	12.50	43.75	37.50	100.00
	% in size category	0.66	0.53	2.41	2.28	1.48
Motor vehicles (36)	Absolute freq.	2	12	12	14	40
	% in the industry	5.00	30.00	30.00	35.00	100.00
	% in size category	1.32	3.21	4.12	5.32	3.70
Ship building (37)	Absolute freq.	0	3	1	2	6
	% in the industry	0.00	50.00	16.67	33.33	100.00
	% in size category	0.00	0.80	0.34	0.76	0.56
Other motor vehicles (38)	Absolute freq.	0	1	4	3	8
	% in the industry	0.00	12.50	50.00	37.50	100.00
	% in size category	0.00	0.27	1.37	1.14	0.74
Precision instruments (39)	Absolute freq.	1	1	0	2	4
	% in the industry	25.00	25.00	0.00	50.00	100.00
	% in size category	0.66	0.66	0.00	0.76	0.37

Table 1 (cont.)
Distribution of firms by industry and by size

		Small	*Medium 1*	*Medium 2*	*Large*	*Total*
Non-elaborated Food (41)	Absolute freq.	22	39	26	25	112
	% in the industry	19.64	34.82	23.21	22.32	100.00
	% in size category	14.47	10.43	8.93	9.51	10.37
Elaborated food, tobacco and alcoholic drinks (42)	Absolute freq.	23	22	15	20	80
	% in the industry	28.75	27.50	18.75	25.00	100.00
	% in size category	15.13	5.88	5.15	7.60	7.41
Basic Textile (43)	Absolute freq.	11	19	24	22	76
	% in the industry	14.47	25.00	31.58	28.95	100.00
	% in size category	7.24	5.08	8.25	8.37	7.04
Leather (44)	Absolute freq.	2	9	7	3	21
	% in the industry	9.52	42.86	33.33	14.29	100.00
	% in size category	1.32	2.41	2.41	1.14	1.94
Garment (45)	Absolute freq.	4	22	20	10	56
	% in the industry	7.14	39.29	35.71	17.86	100.00
	% in size category	2.63	5.88	6.87	3.80	5.19
Wood and furniture (46)	Absolute freq.	6	18	13	6	43
	% in the industry	13.95	41.86	30.23	13.95	100.00
	% in size category	3.95	4.81	4.47	2.28	3.98
Cellulose transformation and paper edition (47)	Absolute freq.	8	25	18	15	66
	% in the industry	12.12	37.88	27.27	22.73	100.00
	% in size category	5.26	6.68	6.19	5.70	6.11
Plastic materials (48)	Absolute freq.	9	13	16	4	42
	% in the industry	21.43	30.95	38.10	9.52	100.00
	% in size category	5.92	3.48	5.50	1.52	3.89
Other non-basic industries (49)	Absolute freq.	4	8	6	5	23
	% in the industry	17.39	34.78	26.09	21.74	100.00
	% in size category	2.63	2.14	206	1.90	2.13
Total	Absolute freq.	152	374	291	263	1080
	% in the industry	14.07	34.63	26.94	24.35	100.00
	% in size category	100.00	100.00	100.00	100.00	100.00

Note:
Small means "Firm's average number of employees lower or equal than 25".
Medium 1 means "Firm's average number of employees higher than 25 and lower or equal than 50".
Medium 2 means "Firm's average number of employees higher than 50 and lower or equal than 75".
Large means "Firm's average number of employees higher than 75".
Percentages in parentheses.

Table 2
Descriptive Statistics (Weighted averages)

%	Year					
	1986	**1987**	**1988**	**1989**	**1990**	**1991**
Rates of growth						
Real Output		8.28	7.83	7.82	0.06	0.04
Employment		1.65	1.88	1.87	-0.82	-2.21
Permanent		0.41	0.32	-0.33	-1.41	-1.75
Nonproduction		1.91	1.89	1.52	1.60	0.83
Production		-0.37	-0.51	-1.32	-3.10	-3.26
Temporary		22.82	23.50	26.70	4.41	-6.04
Wages		9.23	6.26	7.09	9.72	8.98
Permanent		9.11	6.45	7.64	9.26	8.82
Nonproduction		10.23	7.33	8.89	8.38	8.74
Production		7.99	5.57	6.04	9.05	7.91
Temporary		14.84	8.98	8.13	13.06	6.63
Investment rate		6.06	6.81	6.81	7.63	7.44
Net investment rate		1.76	2.47	2.29	2.79	2.31
Capital-labour ratio	6.75	6.64	6.56	6.47	6.59	6.78
Labour shares (in percentage of total employment)						
Permanent	94.45	93.28	91.85	89.87	89.33	89.75
Nonproduction	32.10	32.20	32.20	32.10	32.87	33.90
Production	62.35	61.08	59.65	57.77	56.46	55.85
Temporary	5.55	6.72	8.15	10.13	10.67	10.25

Table 3
Percentage of Firms by Movements and Type of Employment and by Year

Type of labour	Movement	Year				
		1987	1988	1989	1990	1991
Permanent	No Change	20.28	18.52	18.70	17.87	19.90
	Hiring	42.96	43.80	41.02	36.20	34.54
	Firing	36.76	37.68	40.28	45.93	45.56
Nonproduction	No Change	45.65	40.09	40.28	39.81	41.85
	Hiring	32.87	38.89	35.56	34.36	31.57
	Firing	21.48	21.02	24.16	25.93	26.58
Production	No Change	25.37	22.96	22.59	21.76	23.33
	Hiring	37.87	38.71	37.96	33.06	31.67
	Firing	36.76	38.33	39.45	45.18	45.00
Temporary	No Change	4.54	5.00	5.19	5.19	6.39
	Hiring	76.02	74.35	74.07	64.35	58.52
	Firing	19.44	20.65	20.74	30.46	35.09

Table 4
Percentage of Observations by Movements and Type of Employment and by Size (1987-1991)

Type of labour	Movement	Size				
		Small	*Medium 1*	*Medium 2*	*Large*	*Total*
Permanent	No Change	44.34	23.90	12.30	5.02	19.06
	Hiring	29.21	40.54	42.75	41.22	39.70
	Firing	26.45	35.56	44.95	53.76	41.24
Nonproduction	No Change	68.82	55.45	34.30	13.99	41.54
	Hiring	18.81	26.74	41.17	47.56	34.63
	Firing	12.37	17.81	24.53	38.25	23.83
Production	No Change	47.24	29.73	15.88	8.14	23.20
	Hiring	29.60	35.94	38.83	36.04	35.85
	Firing	23.16	34.33	45.29	55.82	40.95
Temporary	No Change	8.95	6.04	4.06	3.34	5.26
	Hiring	71.45	71.39	70.10	64.87	69.46
	Firing	19.60	22.57	25.84	31.79	25.28

Note: See Note to Table 1

Table 5
Probit model for the probability of the adjustments in permanent production and nonproduction workers

Variable	Year 1988	1989	1990	1991
$ln(L^1_{i,t-2})$	0.2474	0.4507	0.4485	0.4349
	(0.0965)	(0.0844)	(0.0878)	(0.0868)
$ln(L^2_{i,t-2})$	0.0441	0.1023	0.1998	0.3227
	(0.1082)	(0.0886)	(0.0917)	(0.0941)
$ln(L^3_{i,t-2})$	0.0964	0.0038	0.0773	0.0814
	(0.0826)	(0.0749)	(0.0752)	(0.0746)
$L^3_{i,t-2}/L_{i,t-2}$	0.5057	0.4667	0.1989	0.3729
	(0.6458)	(0.6045)	(0.6425)	(0.6116)
Med1	0.1481	0.0996	0.3372	-0.1697
	(0.2711)	(0.2244)	(0.2721)	(0.2288)
Med2	0.5477	0.1438	0.3607	-0.0367
	(0.3220)	(0.2863)	(0.3311)	(0.2977)
Large	07803	0.1782	0.2349	-0.5039
	(0.4233)	(0.3926)	(0.4319)	(0.4132)
$\Delta ln(L^1_{i,t-2})$	0.0737	-0.7217	0.2584	-0.5396
	(0.0787)	(0.3029)	(0.2891)	(0.3361)
$\Delta ln(L^2_{i,t-2})$	-0.0275	0.5668	0.3858	0.0838
	(0.0790)	(0.2925)	(0.3054)	(0.2071)
$\Delta ln(L^3_{i,t-2})$	-0.0860	-0.1766	0.0402	-0.0521
	(0.0358)	(0.0784)	(0.0686)	(0.0652)
$\Delta lnY_{i,t-2}$	0.0819	0.2156	-0.0629	0.1237
	(0.0628)	(0.2762)	(0.3146)	(0.2823)
$I(\Delta L^1_{i,t-2}>0)$	0.3438	0.2315	0.3617	0.2646
	(0.4611)	(0.1201)	(0.1258)	(0.1265)
$I(\Delta L^2_{i,t-2}>0)$	5.5457	0.3713	0.2277	-0.0241
	(1142.1)	(0.1406)	(0.1425)	(0.1433)
$I(\Delta L^1_{i,t-2}<0)$	0.4118	0.0873	0.2625	0.1090
	(0.4626)	(0.1364)	(0.1429)	(0.1392)
$I(\Delta L^2_{i,t-2}<0)$	5.4641	0.3434	0.2738	0.0482
	(1140.1)	(0.1364)	(0.1436)	(0.1395)
Goodness-of-fit statistics				
% Right predictions				
Negative $(D_{it}D_{i,t-1}=0)$	87.50	86.92	85.05	86.50
Positive $(D_{it}D_{i,t-1}=1)$	60.11	60.00	64.69	61.63
Pseudo-R^2	0.24	0.27	0.28	0.27

Note: L^1, L^2 and L^3 denote the number of permanent nonproduction, permanent production and temporary employees respectively; Y denotes value added; *ln* is the natural logarithm and Δ is the difference operator. *Med1, Med2* and *Large* are dummy variables denoting firm size (see Table 1). $I(x \in A)$ is the indicator function, which takes value 1 if $x \in A$ is true, and zero otherwise. Industry dummies and a constant term were included in estimations. Standard errors in parentheses.

Table 6
Percentage of firms by sign of adjustment in different labour inputs

		Year				
		1987	**1988**	**1989**	**1990**	**1991**
Change in permanent nonproduction vs. change in permanent production	*Equal sign*	28.70	29.26	33.24	29.54	30.28
	Opposite sign	16.94	22.04	19.35	23.43	20.18
Change in permanent nonproduction vs. change in temporary	*Equal sign*	30.09	35.46	32.96	31.94	28.33
	Opposite sign	22.68	23.15	24.72	26.20	27.41
Change in permanent production vs. change in temporary	*Equal sign*	39.54	38.33	37.78	33.15	33.15
	Opposite sign	32.96	36.94	36.57	42.04	39.26

Table 7
GMM estimation of the system of Euler equations for permanent nonproduction and production workers

	Third-degree polynomial (5.a)			Second-degree polynomial (5.b)	
Adjustment costs					
Permanent Nonproduction	γ_{11}	1.1762 (0.6562)	Permanent Nonproduction	γ_{11}^{P}	0.3385 (0.4150)
	δ_1	-0.5162 (0.6131)		γ_{11}^{N}	0.7846 (0.4496)
Permanent Production	γ_{22}	0.6376 (0.5307)	Permanent Production	γ_{22}^{P}	0.1050 (0.6970)
	δ_2	-0.0620 (0.2269)		γ_{22}^{N}	1.4869 (1.2405)
Cross-adjustment effects	γ_{12}	2.1522 (0.8158)	Cross-adjustment effects	γ_{12}	0.9419 (0.4420)
	γ_{13}	0.0103 (0.0071)		γ_{13}	0.0032 (0.0039)
	γ_{23}	0.0214 (0.0088)		γ_{23}	0.0195 (0.0121)
Technology					
Permanent Nonproduction	β_1	-0.0025 (0.0023)	Permanent Nonproduction	β_1	-0.0007 (0.0014)
Permanent Production	β_2	-0.0006 (0.0009)	Permanent Production	β_2	-0.0006 (0.0009)
Joint effect	β_0	0.0263 (0.0114)	Joint effect	β_0	0.0163 (0.0075)
Selectivity correction terms					
Permanent Nonproduction	σ_{90}^{1}	-0.1236 (0.1414)	Permanent Nonproduction	σ_{90}^{1}	-0.0459 (0.0844)
	σ_{91}^{1}	-0.8861 (0.3635)		σ_{91}^{1}	-0.2915 (0.1869)
Permanent Production	σ_{90}^{2}	0.0078 (0.0412)	Permanent Production	σ_{90}^{2}	0.0166 (0.0736)
	σ_{91}^{2}	-0.6219 (0.2779)		σ_{91}^{2}	-0.2313 (0.2197)
Specification test					
	J test (df)	30.17 (22)		J test (df)	30.97 (22)
	p-value	0.11		p-value	0.10

Note: Time dummies included in all equations. Heteroscedasticity-robust asymptotic std. errors are reported in parentheses. J is the Hansen-Sargan test of overidentifying restrictions, asymptotically distributed as a χ^2 with as many degrees of freedom as the number of overidentifying restrictions under the null of validity of the instruments; p-value is the significance level above which the null hypothesis is rejected.