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**THE IMPACT OF LABOUR TURNOVER:  
THEORY AND EVIDENCE FROM  
UK MICRO-DATA**

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# **The Impact of Labour Turnover: Theory and Evidence from UK Micro-Data**

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## **Abstract**

We analyse the impact of labour turnover on profits. We extend the efficiency wage model of Salop (1979) by separating incumbent and newly hired workers in the production function. We show that an exogenous increase in the turnover rate can increase profits, but only where firms do not choose the wage. This effect of turnover varies across firms as it depends on turnover costs, the substitutability of incumbents and new hires and other factors. We test our model on UK cross-sectional establishment-level data. We find that our predictions are consistent with the data.

Keywords: Labour Turnover, Turnover Costs, Optimal Turnover  
JEL: J21, J23, E3, F4

## 1. Introduction

Labour turnover is an important and pervasive feature of the labour market. In OECD countries something like 10-15% of workers quit their jobs every year (OECD Economic Outlook, 1999). Since employment rarely changes by more than 1-2% a year, this means that the movement of workers between jobs is much greater than changes in the number of jobs. A good understanding of labour turnover is therefore important for any analysis of the labour market.

Labour turnover affects both workers and firms. Workers experience disruption, the need to learn new job-specific skills and find different career prospects<sup>1</sup>. Firms suffer the loss of job-specific skills, disruption in production and incur the costs of hiring and training new workers. But incoming workers may be better educated, more skilled and have greater initiative and enthusiasm than those who leave. The impact of turnover on workers is quite well understood. However, we know very little about the impact of turnover on firms. This is due to limited availability of data, which has allowed only sporadic study of these issues (turnover and hiring costs have been studied by Burgess and Dolado, 1989, Hammermesh, 1995 and Hammermesh and Pfann, 1996, while Hutchinson et al, 1997, and Kersley and Martin, 1997, have analysed the impact of turnover on productivity). The theory used to explain the impact of turnover on firms is mostly based on the well known efficiency wage model of Salop (1979)<sup>2</sup>. In this model there is no aggregate uncertainty but the context is one of labour market search and matching where workers have private uncertainty on differing job attributes of firms, which they only learn upon becoming employed. Firms choose the wage so as to minimise the marginal cost of labour, balancing the marginal effect of higher wages against the marginal reduction in training costs induced by higher wages. In an earlier, similar setting Schlicht (1978) shows that natural unemployment is induced by excessive labour mobility in the face of high turnover costs. More recently, in the context of a dynamic search model where a continuum of firms choose permanent wage offers and workers sequentially sample from those, Burdett and Mortensen (1998) show that

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<sup>1</sup> The beneficial effects of changed career prospects presumably outweigh the costs, since almost all turnover is initiated by workers. The causes of labour turnover have been extensively studied: see for example Garcia-Serrano (1998), Chow et al. (1999), Tran and Perloff (2002), Roy (2002), Theodossiou (2002), Gautier et al. (2002), Taplin et al. (2003), Clark (2004) and Leuven (2005).

<sup>2</sup>On the interaction between turnover and wages see Shapiro and Stiglitz (1984), Stiglitz, (1985); more recently Munasinghe (2000), Strand (2002) and Toulemonde (2003). Schlicht (2001) shows that efficiency wages paid in the presence of turnover lead to a sub-optimal wage structure.

firms paying high wages and making low profits per worker experience low turnover, while firms paying low wages and making high profits have high turnover<sup>3</sup>.

This paper uses a dataset that allows a more systematic investigation of these issues. We analyse cross-sectional, establishment-level data on whether turnover is regarded (by managers) as "too high", "too low" or "about right". We interpret the responses to these questions as reflecting the impact of turnover on profits. So we assume that managers will report that turnover is "too high" if an exogenous increase in the turnover rate leads to a marked reduction in profits, that turnover is "too low" if an exogenous increase in the turnover rate leads to a marked increase in profits and that turnover is "about right" if an exogenous change in the turnover rate has little impact on profits.

In our data, 25% of establishments report that turnover is "too high", 71% report that it is "about right" and 4% report that it is "too low". This suggests that the impact of turnover varies between firms, especially since some establishments reporting that turnover is "too high" have a lower turnover rate than those reporting that turnover is "too low". The fact that small but statistically significant numbers of establishments report that turnover is "too low" implies that increased turnover can increase profits.

This feature leads us to develop a new theoretical model of the impact of turnover on profits, since in existing models these are always reduced by turnover. We extend the model of Salop (1979) by distinguishing between newly hired and incumbent workers, since the latter have more job-specific human capital but may have less general human capital. A higher turnover rate implies that the proportion of new hires in the workforce is larger. If this causes a sufficiently large increase in productivity then an increase in turnover can increase profits, leading managers to report that turnover is "too low" (and vice-versa). We show that this effect is possible, but only when firms do not unilaterally choose the wage – for example when the wage is negotiated with a union or set nationally. When the firm chooses the wage unilaterally, as in Salop's original model, we confirm that the impact of turnover on profits is negative.

Our model also shows that the impact of turnover on profits depends on a number of factors including the elasticity of substitution between new hires and

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<sup>3</sup> Both firms have the same expected payoffs (where the high wage firms compensate low profits per

incumbents, other exogenous components of the production function and the cost of hiring and training new workers. Since these features vary between firms, our model can explain why the impact of turnover on profits also varies between firms. We use this latter feature in developing our empirical model. We estimate an econometric model of the decision to report turnover as being “too low”, “about right” or “too high”, using characteristics of the workplace and workforce as explanatory variables that may affect the impact of turnover on productivity and hiring and training costs.

We obtain a number of interesting results. We find that a measure of the cost of hiring new workers is associated with a higher propensity to report that turnover is “too high” and with a lower propensity to report that turnover is “too low”. This confirms our prediction that higher turnover costs unambiguously reduce profits. A measure of the amount of training required by new workers has similar effects. Since more training implies higher turnover costs, this fact supports the empirical importance of these costs. But more training may also be a characteristic of establishments where job-specific skills are more important. This indicates that newly hired workers may be less productive than incumbents in these establishments, suggesting that higher turnover could reduce productivity. The negative effect of training is therefore also consistent with an effect of turnover on productivity. The effects of organised labour, measured by the presence of a works council – a formal body that discusses workplace issues – are more complex. A works council is associated with a greater propensity to report that turnover is “too low”. This is consistent with our model’s prediction that turnover can only increase profits when firms do not choose the wage unilaterally. But establishments with works councils are also more likely to report that turnover is “too high”. This may be because the presence of unions implies higher turnover costs (Booth, 1995). We find that a measure of the sharing of knowledge, ideas and skills within the workforce is associated with a lower propensity to report that turnover is “too high” and a higher propensity to report that turnover is “too low”. Since productivity may be less dependent on particular workers, higher turnover is more likely to raise output and thus to be reported as “too low”.

The paper is structured as follows. Section 2 develops our theoretical model. Section 3 develops our empirical model and explains how we might estimate the

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worker by their larger size).

lower and upper bounds to “optimal” turnover. Section 4 describes our data and explanatory variables. Section 5 contains our parameter estimates and our estimates of the lower and upper bounds to turnover. Section 6 concludes.

## 2. A Model of the Impact of Turnover on Profit

Our model is the simplest possible. Output depends on the labour input of newly hired and incumbent workers. New hires and incumbents may have different levels of job-specific and human capital and so may not be perfect substitutes in production. We formalise this by writing the production function as  $Y = F(h, I, \lambda, \sigma)$ , where  $h$  is the number of new hires,  $I$  is the number of incumbents,  $\lambda$  summarises exogenous production-specific factors and  $\sigma$  is the elasticity of substitution between new hires and incumbents. The production function satisfies  $F_h > 0$ ,  $F_{hh} < 0$ ,  $F_I > 0$ ,  $F_{II} < 0$ ,  $F_\lambda > 0$ ,  $F_{\lambda\lambda} < 0$ ,  $F_{hI} > 0$ ,  $F_{h\lambda} > 0$  and  $F_{I\lambda} > 0$ . If new hires and incumbents are perfect substitutes then  $\sigma \rightarrow \infty$  and production simplifies to  $Y = F(N, \lambda, \sigma)$ , where  $N$  is total employment. Due to legal constraints, the firm pays all workers the same wage  $w > 0$ . The fixed unit cost of hiring and training new workers is  $\tau > 0$ . We consider only the steady state<sup>4</sup> and normalise output price to unity. Profits are:

$$(1) \quad \Pi = F(h, I, \sigma, \lambda) - w(h + I) - \tau h$$

The per-period turnover rate - that is, the proportion of the existing workforce who quit - is defined as  $q$ , and depends on the wage and on other factors:

$$(2) \quad q = q(w, \theta)$$

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<sup>4</sup> A previous dynamic version of our model (available on request) specifies a current-value Hamiltonian problem where, under the initial simplifying assumption of a competitive labour market, the first order condition selects the control variable (new hires), while state (incumbents) and co-state variables are determined by two differential equations. However, the disadvantage of adopting such a dynamic specification is that, from that point onwards, the functional form of the production function must be specified to carry on the analysis. The steady state representation does not capture inter-temporal trade-offs but is more direct for illustration purposes, while still allowing implicit general function forms everywhere, as in Salop (1979).

where  $\theta$  is exogenous<sup>5</sup> and  $q_w < 0$ ,  $q_{ww} > 0$ ,  $q_\theta > 0$ ,  $q_{\theta\theta} < 0$  and  $q_{w\theta} < 0$ .  $qN$  workers leave the establishment in every period. This implies that  $h = qN$  and  $I = (1 - q)N$ . Profits become:

$$(3) \quad \Pi = F(qN, (1 - q)N, \sigma, \lambda) - (w + \tau q)N$$

where  $w + \tau q$  is the marginal cost of labour<sup>6</sup>.

### 2.1 Choice of Employment and Wage

We first consider the case where the firm chooses both employment and the wage, as in Salop (1979). At an interior solution<sup>7</sup>, the first-order conditions for employment and the wage are:

$$(4) \quad \Pi_N = qF_h + (1 - q)F_I - (w + \tau q) = 0$$

$$(5) \quad \Pi_w = N[q_w(F_h - F_I) - (1 + \tau q_w)] = 0$$

Equation (4) equates the marginal product of labour to its marginal cost. Equation (5)

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<sup>5</sup>  $\theta$  includes the general market wage that workers expect to be able to earn if they leave the firm; for example in Salop the turnover function is  $q = q(w/\theta)$ , where  $\theta$  denotes "...a measure of labour market tightness, say the average wage rate adjusted for the probability of getting a job (and including the average non-pecuniary utility)" (Salop, 1979, p. 119).

<sup>6</sup> To keep matters simple, we are not explicitly considering firing costs in the profit function. With fixed firing costs  $\varphi > 0$ , this is without loss of generality, since expressions (1) and (3) become:

$$\Pi = F(h, I, \sigma, \lambda) - w(h + I) - \tau h - \varphi I$$

and:

$$\Pi = F(qN, (1 - q)N, \sigma, \lambda) - (w + \tau q + \varphi(1 - q))N$$

respectively, with new marginal cost of labour  $w + \tau q + \varphi(1 - q)$  and the subsequent theoretical analysis unchanged. However firing costs may not always be fixed: for example, they may depend on the length of service, or they may differ across firms even when they are fixed, thus creating firm specific effects. We take this into account in our empirical methodology in Section 3, and we also thank an anonymous referee for pointing this out.

<sup>7</sup> The second order conditions must satisfy:

$$\Pi_{NN} = q^2 F_{hh} + (1 - q)^2 F_{II} < 0$$

$$\Pi_{ww} = N[q^2(F_{hh} - F_{II}) - q_{ww}(F_h - F_I - \tau)] < 0$$

$$\Pi_{NN}\Pi_{ww} - (\Pi_{Nw})^2 > 0, \text{ where:}$$

$$\Pi_{Nw} = \Pi_{wN} = 2q_w[qF_{hh} + (1 - q)F_{II}] < 0$$

states that the marginal impact of the wage on output is balanced with the marginal impact of the wage on the marginal cost of labour. If new hires and incumbents are perfect substitutes then  $F_h - F_l = 0$ . In this case, our model reduces to the model of Salop (1979)<sup>8</sup> and the firm minimises the marginal cost of labour by setting  $-\tau q_w = 1$ .

From the first-order conditions, the optimal levels of employment and wage and consequently the maximum profit function depend on the parameters of the model (elasticity of substitution, production specific factors, training costs and exogenous determinants of the turnover rate). So  $N = N(\sigma, \lambda, \tau, \theta)$ ,  $w = w(\sigma, \lambda, \tau, \theta)$  and  $\Pi = \Pi(\sigma, \lambda, \tau, \theta)$ . From this simple comparative statics gives:

$$(6) \quad \Pi_\theta = N \frac{q_\theta}{q_w} < 0$$

The algebraic derivation of the above expression is detailed in Appendix A.1. The negative sign result arises because a rise in  $\theta$  can only increase profits if, for a given turnover cost, new hires are sufficiently more productive than incumbents at the margin. But since  $q_w < 0$  the first order condition for the wage implies that  $F_h - F_l - \tau < 0$ . So, at the optimal wage, new hires are less productive than incumbents and an increase in  $\theta$  will reduce profits.

## 2.2 Choice of Employment only

Suppose now that the firm does not choose the wage unilaterally. In the UK, this is most likely due to the presence of a trade union. If the firm negotiates the wage with a union, the wage will reflect all factors relevant to both firm and union, as well as their relative bargaining power. In this case the wage is equal to a fixed function  $w = w(\sigma, \lambda, \tau, \theta, \beta)$ , where the new parameter  $\beta$  captures the effects of union concerns and bargaining<sup>9</sup>.

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<sup>8</sup> Combining (4) and (5) we obtain a Solow (1979) type condition  $(w - F_l)q_w / q = 1$ , showing that the elasticity of turnover with respect to the wage (net of the incumbents' productivity) is equal to one.

<sup>9</sup> For example, a model of wage determination reflecting this relationship is in Garino and Martin (2000), where  $w = \mu(\cdot)W_0$ , the markup  $\mu(\cdot)$  is a function of exogenous factors including  $\theta$ ,  $\sigma$ ,  $\lambda$ ,  $\tau$ ,  $\beta$  and  $W_0$  indicates the general market wage. Note that when the wage is equal to a fixed function  $w = w(\sigma, \lambda, \tau, \beta, \theta) = w(\cdot, \theta)$  set by the union then the general turnover function



There is only a first-order condition for employment - equation (4) - so the impact of turnover on profits becomes:

$$(7) \quad \Pi_{\theta} = N[(F_h - F_l - \tau)(q_w w_{\theta} + q_{\theta}) - w_{\theta}]$$

The derivation of (7) is detailed in Appendix A.2. The term  $q_w w_{\theta} + q_{\theta}$  is the total derivative of  $q$  with respect to  $\theta$ , which increases the number of new hires by  $q_w w_{\theta} + q_{\theta}$  and reduces the number of incumbents by the same amount. The resulting change in output is then  $(F_h - F_l)(q_w w_{\theta} + q_{\theta})$ , which measures the impact on profits per worker of the change in output induced by a change in  $\theta$ . This effect is ambiguous, since the signs of both  $q_w w_{\theta} + q_{\theta}$  and  $F_h - F_l$  are ambiguous. The sign of  $q_w w_{\theta} + q_{\theta}$  is ambiguous because  $q_{\theta}$  is positive (and  $w_{\theta}$  is expected to be positive) but  $q_w$  is negative; while the sign of  $F_h - F_l$  depends on the assumptions made about the relative productivities of incumbents and new hires. The term  $\tau(q_w w_{\theta} + q_{\theta}) + w_{\theta}$  is the impact on profits per worker of the change in total labour costs induced by the rise in  $\theta$ . Total labour costs,  $w + \tau q$ , are the sum of the wage and training costs. The increase in  $\theta$  increases the wage by  $w_{\theta}$  and changes training costs by  $\tau(q_w w_{\theta} + q_{\theta})$ . The sign of  $\tau(q_w w_{\theta} + q_{\theta}) + w_{\theta}$  is ambiguous. Overall, therefore, the sign of (7) is ambiguous. Below we show that both cases of a positive and a negative sign are possible.

### 2.3 The Optimal Turnover Rate

We define the “optimal turnover rate”, denoted  $\hat{q}$ , as the turnover rate at which a change in the exogenous component of turnover,  $\theta$ , has no effect on profits. That is,  $q = \hat{q}$  where  $\Pi_{\theta} = 0$ . Assuming a solution to this equation exists, we can show the following result:

#### **Proposition:**

When wages are fixed in negotiations and firms can only choose employment, the

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$q = q(w, \theta)$  (valid when the wage is a choice variable) becomes  $q(w(\cdot, \theta), \theta) = \gamma(\cdot, \theta)$ , thus taking on a new form in  $\theta$ . We are grateful to an anonymous referee for pointing this out.

impact of turnover on profits is positive when turnover is “too low” and negative when turnover is “too high”. That is,  $\Pi_\theta > 0$  for  $q < \hat{q}$  and  $\Pi_\theta < 0$  for  $q > \hat{q}$ .

The proof is in Appendix A.3; and an illustration is given in Figure 1, which plots  $\Pi_\theta$  as a continuous decreasing function of  $q$  where  $\Pi_\theta = 0$ , uniquely, at  $q = \hat{q}$ .

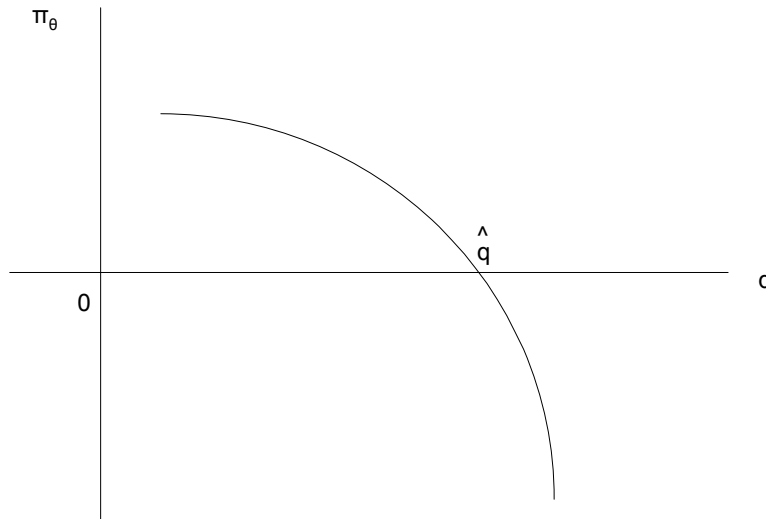


Figure 1

So when firms cannot choose the wage unilaterally, the theory cannot unambiguously predict whether a change in the exogenous determinants of turnover will ultimately raise or lower profits. In contrast to Salop (1979), both sign outcomes are possible, according to whether turnover is perceived as being too high or too low.

Moreover, from the derivative of the maximum profit function with respect to the exogenous determinants of turnover - expression (7) - the impact of turnover on profits depends on all the parameters of the model - which vary between firms - and on the relative productivities of incumbents and new hires.

### 3. Methodology

In this section we develop an empirical model of the impact of labour turnover on profits, based on the theoretical model developed above. We have data on responses to the question:

*Is the rate of turnover too high, too low or about right?*

We assume that responses reflect the impact of a change in the exogenous component of the turnover rate on profits, that is,  $\Pi_\theta$ . Managers will regard the rate of turnover as exactly right if a change in the exogenous component of the turnover rate does not affect profits, i.e. if  $\Pi_\theta = 0$ . At this point, the actual turnover rate will equal the optimal rate, so  $q_i = \hat{q}_i$ , where  $i$  denotes the single establishment (so it is clear that variations in  $\sigma_i, \lambda_i, \tau_i, \theta_i$  and  $\beta_i$  between establishments will lead the impact of turnover on profits to differ across firms). Managers will report that turnover is “about right” if a change in the exogenous component of the turnover rate has little effect on profits, in which case the actual turnover rate will be close to the optimal rate. They will report that turnover is either “too high” or “too low” if the actual rate of turnover is sufficiently far from the optimal rate for a change in the exogenous component of the turnover rate to have an appreciable affect on profits. We can formalise this by writing:

$$(8.1) \quad \text{turnover is "too low" if} \quad \log q_i < \log q_{Li}$$

$$(8.2) \quad \text{turnover is "about right" if} \quad \log q_{Li} < \log q_i < \log q_{Hi}$$

$$(8.3) \quad \text{turnover is "too high" if} \quad \log q_{Hi} < \log q_i$$

where  $q_{Li}$  and  $q_{Hi}$  are thresholds beyond which turnover will be reported as “too low” or “too high”. Since the turnover rate is non-negative, it is convenient to build in a non-negativity constraint by expressing our model in log linear form<sup>10</sup>.

We next express the optimal turnover rate as:

$$(9) \quad \log \hat{q}_i = \gamma + \delta X_i + \varepsilon_i$$

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<sup>10</sup> Of course, the above inequalities hold also in levels.

Equation (9) is the empirical counterpart of (7).  $X_i$  is a  $(k \times 1)$  vector of explanatory variables that capture the effects of  $(\sigma, \lambda, \tau, \beta)$ ,  $\gamma$  is a constant,  $\delta$  is a  $(1 \times k)$  parameter vector and  $\varepsilon_i$  is an i.i.d. error term.

To complete the model we need expressions for  $q_{Li}$  and  $q_{Hi}$ . We can do this in two ways. First, we might assume that the upper and lower thresholds differ from the optimal turnover rate by constants  $\gamma'_L$  and  $\gamma'_H$ :

$$(10.1) \quad \log q_{Li} = \log \hat{q}_i - \gamma'_L$$

$$(10.2) \quad \log q_{Hi} = \log \hat{q}_i + \gamma'_H$$

Combining (8)-(10), turnover is then:

$$(11.1) \quad \text{"too low" if} \quad \alpha \log q_i - \delta X_i - \varepsilon_i < \gamma_L$$

$$(11.2) \quad \text{"about right" if} \quad \gamma_L \leq \alpha \log q_i - \delta X_i - \varepsilon_i \leq \gamma_H$$

$$(11.3) \quad \text{"too high" if} \quad \alpha \log q_i - \delta X_i - \varepsilon_i > \gamma_H$$

where  $\gamma_L = \gamma - \gamma'_L$ ,  $\gamma_H = \gamma + \gamma'_H$  and we expect  $\alpha = 1$ . The three possible responses to the question above have a clear ordered structure. We therefore choose to estimate equation (11) using Ordered Probit techniques.

Alternatively, we might allow the thresholds to depend on the factors that determine optimal turnover, i.e.:

$$(12.1) \quad \log q_{Li} = \log \hat{q}_i - \gamma'_L - \delta'_L X_i$$

$$(12.2) \quad \log q_{Hi} = \log \hat{q}_i + \gamma'_H + \delta'_H X_i$$

Combining (8), (10) and (12), turnover is then:

$$(13.1) \quad \text{"too low" if} \quad \alpha \log q_i - \delta_L X_i - \varepsilon_i < \gamma_L$$

$$(13.2) \quad \text{"too high" if} \quad \alpha \log q_i - \delta_H X_i - \varepsilon_i > \gamma_H$$

where  $\delta_L = \delta - \delta'_L$  and  $\delta_H = \delta + \delta'_H$ . Equation (13) is a pair of equations with binary dependent variables. We choose to estimate these using Probit techniques.

Estimates of (11) are consistent and efficient if the restrictions:

$$(14) \quad \delta_H = \delta_L \text{ and } \gamma_H = \gamma_L$$

are valid. Estimates of (13.1) and (13.2) are always consistent but are inefficient if the restrictions are valid. Following Ioannides and Rosenthal (1994), we can construct Hausmann (1978) tests of the restrictions using the test statistic:

$$(15) \quad H = H_L + H_H, H_i = (\varphi_{op} - \varphi_{i,pr})(V_{op} - V_{i,pr})^{-1}(\varphi_{op} - \varphi_{i,pr})', i = \{L, H\}$$

where  $\varphi_{op}$  is a  $(1 \times k+1)$  vector containing Ordered Probit estimates from (11),  $\varphi_{Lpr}$  is a  $(1 \times k+1)$  vector containing Probit estimates of (13.1),  $\varphi_{Hpr}$  is a  $(1 \times k+1)$  vector containing Probit estimates of (13.2) and  $V$  is the corresponding  $(k+1 \times k+1)$  variance-covariance matrix.

#### 4. Data and Explanatory Variables

We use data from the 1991 Employer's Manpower and Skills Practices Survey (EMSPS) and the 1990 Workplace Employee Relations Survey (WERS). EMSPS is a nationally representative survey of individual establishments focusing on training, labour turnover and employment practices. Every establishment in EMSPS was also surveyed in the 1990 Workplace Employee Relations Survey (WERS), which has become a primary data source in the labour economics and industrial relations literatures (Millward et al., 1992; Millward, 1993). Combining these data sets provides a rich source of information on establishments and their employees.

We have manager responses for 1675 establishments shown in Table 1.

<< Table 1 here >>

Descriptive statistics are presented in column (i) of Table 1.a. 71% of establishments view turnover as “about right”, 25% as “too high” and 4% as “too low”. The data show that 1594 out of 1675 establishments hired workers during the 12 months prior to the survey. Responses from these establishments are summarised in column (ii). There are also 81 establishments that did not hire workers in the 12 months before the survey, including those that fired workers and those that neither hired nor fired. Their responses are summarised in column (iii). As we would expect, more managers regard turnover as excessive in establishments that hired in the observation period and fewer do in establishments that did not hire. Interestingly, there is no evidence that establishments that do not hire are more likely to regard turnover as low. In the econometric estimates, presented in section 5, non-availability of data reduces our main sample to 914 establishments, all of which hired workers in the previous 12 months. Managers' views on turnover for this sample are summarised in column (iv). The results are similar to those obtained with the full sample (a slightly larger proportion of establishments report that turnover is “too high” and a smaller proportion report that it is “about right”, but these differences are not statistically significant). This suggests that selection itself is not a major issue.

Our first explanatory variable is the actual turnover rate,  $q_i$  (full details of all variables are in the Data Appendix). Our data on this is obtained from responses to the question:

*Taking the establishment's workforce as a whole, what was the percentage rate of turnover of employees for the past 12 months?*

We assume that responses to this question measure departures by workers from the establishment and that these departures are voluntary (see Martin, 2003, for a detailed discussion and an empirical model of the actual turnover rate using the same dataset). Table 1.b shows manager views on turnover at differing rates for our full sample and for the sample of 914 establishments used in our estimates. Managers are significantly more likely to view turnover as too high when the turnover rate is high and significantly less likely to do so when turnover is low. However, these data also display some diversity; and the relationship between responses and the turnover rate is not monotonic. Some establishments that report turnover is “too high” have a lower

turnover rate than other establishments that report that turnover is “too low”, and vice versa. This confirms that the impact of turnover on profits differs between establishments<sup>11</sup>.

Our second set of explanatory variables relates to the costs of hiring and training,  $\tau_i$ . We use a variable that indicates whether managers report that the establishment experienced difficulty in hiring workers in the preceding year as a simple measure of hiring costs. This measure is associated with difficulty in filling vacancies, which also leads to larger hiring costs (Haskel and Martin, 2001). To represent training costs, we use a measure of whether workers who have done similar work before receive training that lasts for 7 days or longer when they join the establishment. This can indicate establishments where workers require specific skills and thus where training costs are higher.

Our third set of variables uses a variety of measures of the presence, influence and activities of trade unions,  $\beta_i$ . In our results we use a measure of whether the establishment has a works council, that is, a formal body in which managers meet with trade unions (Freeman and Lazear, 1995).

Our fourth set of variables reflects the elasticity of substitution between new hires and incumbents,  $\sigma_i$ . We use dummy variables that indicate whether the establishment uses (i) computer-aided design; (ii) computing or data processing; (iii) word processing. We also include measures of whether the establishment attempts to facilitate communication between workers through discussion groups, quality circles or other types of informal meetings which lead to greater sharing of job-specific information, thus making productivity less sensitive to the departure of individual workers (Levine and Tyson, 1990; Kersley and Martin, 1997).

Our fifth set of variables reflects production specific factors,  $\lambda_i$ . We use indicators of whether the establishment produces any goods that use “microprocessors or other microelectronic components” or “new materials such as advanced alloys or engineering plastics”; or had invested in new plant and machinery or new computer applications in the preceding year. We also include manual, skill and sex composition of the workforce and the effects of part-time working and short-term contracts. These

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<sup>11</sup> Evidence suggests that firms are hit by idiosyncratic shocks (see for example Davis and Haltiwanger, 1992): unlucky firms shrink while lucky ones grow. In this context, one might think of the managers of shrinking establishments responding that turnover is ‘too high’, meaning higher than in their preferred state where the firm receives a good shock.

may be important, as different types of worker are likely to have differing training and search costs with different impacts on productivity.

Finally, we use total employment,  $N$ , to measure size effects, the unemployment rate in the local labour market and whether revenue at the establishment is increasing; as well as regional and industry dummies.

## 5. Econometric Estimates

Table 2 shows the estimates of our model.

<< Table 2 here >>

Columns (i) and (ii) contain Probit estimates of (13.1) and (13.2) and column (iii) contains Ordered Probit estimates of (11). These are better determined, as we would expect, while the estimates in column (ii) are least well determined. The Hausman test statistics do not reject the restrictions in (14). It is also worth noting that an informal "likelihood ratio test" fails to reject the restrictions: from the table, we obtain  $-2(L1 + L2 - L3) = 24.3$ , where  $L_k$  is the maximised value of the log likelihood in column  $k$ ; since we estimate 38 parameters, this statistic is not significantly different from zero<sup>12</sup>.

Turning to our estimates and taking Table 2 as a whole, our main results are as follows. First, the turnover rate has a positive effect, as predicted. The estimate is closest to its theoretical value of unity in column (i) but is significantly different from unity in column (iii).

Second, both hiring and training costs are positive. Their effects are clearly significant in column (i) and marginally so in column (iii). Works councils are positive and significant in both columns (i) and (ii), so their existence makes it more likely that turnover is regarded as either "too high" or "too low". Given this, it is not surprising that the estimate is not significant in column (iii). The measure of informal communication is negatively signed throughout, although only clearly significant in column (iii). No other variable is significant.

These estimates are generally consistent with the predictions of our model on the sign and variability of the impact of turnover on profits. Higher training and hiring costs suggest that these costs make it more likely that turnover will be "too high". The

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<sup>12</sup> We note that this test statistic may not be distributed as chi-square; however the fact that the test statistic is less than the degrees of freedom suggests that the null hypothesis would not be rejected for a wide range of distributions of the test statistic under the null.



negative effect of informal communication through bodies such as quality circles suggests that the sharing of experience and ideas is facilitated and that job-specific skills are spread more widely within the workforce, with the result that productivity is less vulnerable to the departure of particular individuals. This is consistent with other evidence that informal communication is associated with higher productivity growth (Levine and Tyson, 1990, Kersley and Martin, 1997). The effects of works councils are more complex. The positive effect in column (ii) supports the argument that turnover is more likely to be reported as “too low” in establishments with more interaction between managers and unions. But the positive effect in column (i) is not. This estimate may reflect the fact that the presence of unions is also associated with higher training and hiring costs.

We considered the robustness of our estimates. Ideally, we would have preferred to estimate our model on an holdout sample derived from a different survey. However, the question from which we derive our dependent variable has not been repeated in subsequent WERS surveys in 1998 and 2004; and we are not aware of this type of question having been asked in any other survey. Therefore it is not possible to do this. We then conducted a number of further experiments using the data we have (the results are not reported for brevity, but are available from the authors). First, we considered endogeneity of the turnover rate. Although our model assumes that the turnover rate is a given function of the wage and other factors, in practice it may be endogenous. We assessed the importance of this by using the econometric model in Martin (2003) to generate predicted values of the actual turnover rate, which we then used to estimate our model. This had little effect. Second, we considered whether our results were affected by the exclusion of establishments with zero turnover rates implied by the use of the logarithmic form. About 4% of establishments report no turnover, so their exclusion is potentially significant. But estimates of models using the level rather than the log of the turnover and hiring rates are very similar to those reported in Table 3 (see below).

In other experiments, we used alternative measures of training, including indicators of whether training was on-the-job or off-the-job, whether incumbent workers continued to receive training, whether the results of training were assessed or certified, whether inexperienced workers received training and whether training was associated with the introduction of new technology. None of these alternative measures were significant, suggesting that the effects of training may not be very

robust. We subdivided our measure of hiring difficulties into separate measures for skilled and unskilled manual and non-manual workers, and we included these in our model. Each measure was individually significant. We experimented with measures of employment change, considering the effects of changes in part-time and full-time employment. These were not significant. So this last set of experiments suggests that our results are robust.

We can use our results to construct estimates of the critical bounds  $q_{Hi}$  and  $q_{Li}$  in Table 3.

<< Table 3 here >>

Panel (a) of Table 3 shows averages and standard deviations of these bounds, constructed using both Probit and Ordered Probit estimates. The average values of the lower bound are 1.7% for Probit and 2.6% for Ordered Probit. Although small, these estimates suggest there are some benefits to turnover. The average values of the upper bound are 21.2% for Probit and 34.7% for Ordered Probit. This disparity is mainly due to differences in the coefficient of the turnover rate. Since the Probit estimate is closer to unity, we would put greater weight on the estimated upper bound. That would place the average value of the upper bound at the lower end of the range. Panel (b) of Table 3 documents differences in the bounds according to the main factors identified in Table 2 (using Probit estimates). There is little variation in the estimates of the lower bound. Estimates of the upper bound, by contrast, differ quite markedly, being lower in establishments with higher turnover costs and higher in establishments with informal communication.

## 6. Conclusions

We present a simple model of the impact of the rate of labour turnover on profits. We enhance the efficiency wage model of Salop (1979), where the rate of turnover is an exogenous function of the wage and of other factors including the general market wage, by distinguishing between incumbent and newly hired workers in the production function. We recover the literature prediction that at the optimal wage the effect of turnover on profits is negative, since, for a given turnover function, profit maximising firms adjust the wage to minimise the cost of labour. We then consider the case in which firms cannot choose the wage unilaterally. In these circumstances the wage still depends on a number of parameters that include the exogenous determinants of turnover, the elasticity of substitution between incumbents and new hires, the actual hiring and

training costs, production specific factors and indicators of the bargaining power of unions. But this functional relationship is fixed in a process of union negotiation; so firms can only choose employment. We show that in this case the impact of an exogenous increase in turnover on the maximum profit function can be positive as well as negative. Also, the effect of turnover on profits varies across firms, since it depends on the parameters of the model - which are different for different firms - and on the productivity gap between incumbent and new hires.

We test the predictions of our model using cross-sectional, firm-level data on whether turnover is regarded by managers as "too high", "about right" or "too low". We assume that responses to this question reflect the impact of turnover on profits; and we estimate Probit and Ordered Probit models of such responses using as explanatory variables the rate of turnover itself and measures of all the relevant parameters in the theoretical model. We find that the data confirm the main predictions of our model and that in general the estimates are robust, suggesting that for most firms where the wage is not set unilaterally the impact of turnover on profits is positive

### Appendix A.1

Expression (6) is derived as follows:

$$(a.1) \quad \begin{aligned} \Pi_{\theta} &= \Pi_N N_{\theta} + \Pi_w w_{\theta} + \Pi_q q_{\theta} = \\ &= [qF_h + (1-q)F_l - (w + \tau q)]N_{\theta} + \\ &+ N[q_w(F_h - F_l) - (1 + \tau q_w)]w_{\theta} + \\ &+ N(F_h - F_l - \tau)q_{\theta} \end{aligned}$$

By the envelope theorem this reduces to:

$$(a.2) \quad \Pi_{\theta} = \Pi_q q_{\theta} = Nq_{\theta}(F_h - F_l - \tau)$$

But by the first order condition in the wage – i.e. (5) – we know that  $q_w = 1/(F_h - F_l - \tau)$ . And since (5) holds at an interior solution, we also know that  $N \neq 0$ . Hence (a.2) can be rewritten as (6) in the text.

### Appendix A.2

Expression (7) is derived by re-arranging:

$$(a.3) \quad \Pi_{\theta} = \Pi_w w_{\theta} + \Pi_q q_{\theta} = N[q_w(F_h - F_l) - (1 + \tau q_w)]w_{\theta} + N(F_h - F_l - \tau)q_{\theta}$$

Note that by the first order condition in employment – i.e. (4) – the above can also be rewritten as:

$$(a.4) \quad \Pi_{\theta} = N[(F_h - F_l - \tau)(q_w w_{\theta} + q_{\theta}) - w_{\theta}] = N \left[ \frac{(w - F_l)(q_w w_{\theta} + q_{\theta})}{q} - w_{\theta} \right]$$

### Appendix A.3

Let  $\hat{\theta}$  denote the solution in  $\theta$  to the equation  $\Pi_{\theta} = 0$ , assuming such a solution exists. From (7) [i.e. (a.4)],  $\Pi_{\theta}$  is a function of the model's parameters  $\sigma, \lambda, \tau, \beta$  and  $\theta$ . Hence solving the equation  $\Pi_{\theta} = 0$  for  $\theta$  implicitly defines  $\hat{\theta}$  as a function

of  $\sigma, \lambda, \tau, \beta$ ; i.e.  $\hat{\theta} = \hat{\theta}(\sigma, \lambda, \tau, \beta)$ . From (2) and from the fixed wage function  $w = w(\sigma, \lambda, \tau, \theta, \beta)$  the optimal turnover rate is then defined as:

$$(a.5) \quad \hat{q} = q(w, \theta) \Big|_{\hat{\theta}} = q(w, \hat{\theta}) = q(w(\sigma, \lambda, \tau, \beta, \hat{\theta}(\sigma, \lambda, \tau, \beta)), \hat{\theta}(\sigma, \lambda, \tau, \beta)) \\ = \hat{q}(\sigma, \lambda, \tau, \beta)$$

Where the notation  $\Big|_{\hat{\theta}}$  indicates that an expression is evaluated *at*  $\hat{\theta}$ . Hence, evaluating (7) [i.e. (a.4)] at  $(\hat{\theta}, \hat{q})$ , equating to zero, and solving for  $\hat{q}$ , makes the condition  $\Pi_{\theta} = 0$  equivalent to<sup>13</sup>:

$$(a.6) \quad \hat{q} = q(w, \theta) \Big|_{\hat{\theta}} = [(q_w w_{\theta} + q_{\theta})(F_h - F_l - \tau) / w_{\theta}] \Big|_{\hat{\theta}} = [(q_w w_{\theta} + q_{\theta})(w - F_l) / w_{\theta}] \Big|_{\hat{\theta}}$$

Alternatively, solving for  $q_{\theta}$ , the condition  $\Pi_{\theta} = 0$  is also equivalent to:

$$(a.7) \quad q_{\theta} \Big|_{\hat{\theta}} = w_{\theta} [(1 / (F_h - F_l - \tau)) - q_w] \Big|_{\hat{\theta}} = w_{\theta} [(q / (w - F_l)) - q_w] \Big|_{\hat{\theta}} > 0$$

since by assumption  $q_{\theta} > 0$ . As we expect  $w_{\theta} > 0$ , for (a.7) to be positive then the condition  $1 / (F_h - F_l - \tau) = q / (w - F_l) > q_w$  must hold<sup>14</sup>. But since  $q_w < 0$ , this condition is not restrictive, as it is compatible with both possibilities  $F_h - F_l - \tau > 0$  and  $F_h - F_l - \tau < 0$  on the sign of the relative productivities of incumbents and new hires<sup>15</sup>. Given this, we can prove the proposition as follows:

**Proof:**

From (7) [i.e. (a.4)],  $\Pi_{\theta} > 0$  is equivalent to:

$$q < (q_w w_{\theta} + q_{\theta})(w - F_l) / w_{\theta}$$

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<sup>13</sup>  $\Pi_{\theta}$  is the derivative of the maximum profit function with respect to  $\theta$ : since the first order condition for employment holds at an interior solution, we have again  $N \neq 0$ .

<sup>14</sup> Compare this to the case in which *both* employment and the wage are optimally chosen, where this condition holds as an equality.

<sup>15</sup> On the other hand, if  $w_{\theta} < 0$ ,  $1 / (F_h - F_l - \tau) = q / (w - F_l) < q_w < 0$  must hold for (a.7) to be positive: this is still fully consistent with our result (which does not depend on the sign of  $w_{\theta}$ ).

(so long as  $q = \frac{w - F_I}{F_h - F_I - \tau} > 0$ , which we reasonably expect to hold); and  $\Pi_\theta < 0$  is

equivalent to:

$$q > (q_w w_\theta + q_\theta)(w - F_I) / w_\theta$$

Denote the RHS of the above inequalities as:

$$(q_w w_\theta + q_\theta)(w - F_I) / w_\theta = f(q(\cdot, \theta), \theta)$$

So  $\Pi_\theta > 0 \Leftrightarrow q < f(q(\cdot, \theta), \theta)$  and  $\Pi_\theta < 0 \Leftrightarrow q > f(q(\cdot, \theta), \theta)$ .

Now, when  $\theta \rightarrow \hat{\theta}$ , then  $\Pi_\theta \rightarrow 0$ , and:

$$f(q(\cdot, \theta), \theta) \rightarrow f(q(\cdot, \hat{\theta}), \hat{\theta})$$

That is:

$$\lim_{\theta \rightarrow \hat{\theta}} f(q(\cdot, \theta), \theta) = f(q(\cdot, \hat{\theta}), \hat{\theta}) = \hat{q}$$

by (a.6). Hence, by continuity, the proposition must hold.

**Table 1**  
**Descriptive Statistics on Turnover**

**(a) Manager Views on Turnover**

	(i)	(ii)	(iii)	(iv)
	Full sample	Hiring establishments	Non-hiring establishments	Empirical sample
Too high	24.5	26.7	7.7 (*)	30.3
About right	71.2	69.2	89.9 (*)	63.7
Too low	4.3	4.6	2.4	6.0
N	1675	1594	81	914

Notes:

- 1) The table documents responses to the question "Is the rate of turnover too high, too low or about right?"
- 2) Responses are weighted to correct for the deliberate over-sampling of large establishments (see Millward et al, 1992).
- 3) "Full sample" refers to all establishments for which data on turnover is available; "hiring" and "non-hiring" establishments refer to the subset of these that did and did not hire workers in the preceding 12 months; "empirical sample" is the set of establishments used in econometric estimates reported below.
- 4) In all tables (\*) denotes a mean for any of the sub-samples that is significantly different from the full sample average at the 5% level.

**(b) Views on Turnover categorised by Turnover Rate**

<i>(i) Full sample</i>					
	Turnover rate is:				
	≤2%	≤5%	≤10%	≥10%	≥25%
Too high	1.0 (*)	2.4 (*)	9.0 (*)	39.1 (*)	49.2 (*)
About right	89.7 (*)	89.2 (*)	84.3 (*)	59.2 (*)	49.0 (*)
Too low	9.3 (*)	8.4 (*)	6.6	1.7 (*)	1.8 (*)
N	217	513	941	956	370

<i>(ii) Empirical sample</i>					
	Turnover rate is:				
	≤2%	≤5%	≤10%	≥10%	≥25%
Too high	0.1 (*)	6.9 (*)	14.6 (*)	45.0 (*)	60.7 (*)
About right	80.2 (*)	79.9 (*)	75.4 (*)	53.5 (*)	38.7 (*)
Too low	18.5 (*)	13.1 (*)	9.9 (*)	1.5 (*)	0.6 (*)
N	81	259	526	531	150

**Table 2**  
**Econometric Estimates**

	(i)	(ii)	(iii)
Estimation method	Probit	Probit	Ordered Probit
Model	Equation (13.2): Turnover "too high"	Equation (13.1): Turnover "too low"	Equation (11)
Log turnover rate	0.907 (0.076) (*)	-0.570 (0.095) (*)	0.750 (0.057) (*)
Train $\geq$ 7 days	0.296 (0.123) (*)	0.082 (0.191)	0.194 (0.107) (*)
Hiring difficulties	0.329 (0.117) (*)	-0.201 (0.165)	0.255 (0.096) (*)
Works council	0.245 (0.115) (*)	0.385 (0.170) (*)	0.051 (0.097)
Informal communication	-0.197 (0.119) (*)	0.330 (0.206) (*)	-0.222 (0.102) (*)
Computer-aided design	-0.053 (0.125)	0.136 (0.194)	-0.066 (0.105)
Computing/data processing	0.345 (0.189) (*)	-0.256 (0.256)	0.249 (0.151)
Word processing	0.128 (0.160)	-0.277 (0.228)	0.211 (0.133)
High-tech products	-0.096 (0.205)	-0.402 (0.314)	0.077 (0.168)
New plant and machinery	0.009 (0.109)	-0.063 (0.171)	0.035 (0.093)
New computer applications	0.131 (0.117)	0.182 (0.191)	0.062 (0.098)
% skilled	0.162 (0.344)	-0.559 (0.664)	0.184 (0.298)
% manual	0.166 (0.211)	-0.157 (0.361)	0.197 (0.183)
% part-time	-0.134 (0.268)	0.151 (0.420)	-0.156 (0.226)
% female	0.275 (0.322)	-0.339 (0.524)	0.389 (0.271)
% short-term	0.253 (0.496)	0.230 (0.690)	0.097 (0.426)
Revenue increasing	0.067 (0.117)	-0.079 (0.185)	0.076 (0.099)
Local unemployment rate	-0.009 (0.021)	0.037 (0.033)	-0.016 (0.018)
Log employment	-0.013 (0.039)	-0.011 (0.065)	0.001 (0.034)
Regional dummies	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes
$\tau_L$		-3.911 (0.933)	-3.205 (0.317)
$\tau_H$	0.649 (0.593)		-0.621 (0.477)
<b>H (d.o.f)</b>		<b>73.89 (38)</b>	
Number of observations	914	914	914
R <sup>2</sup>	0.224	0.194	0.178
Log L	-435.39	-167.37	-614.91

Notes:

- 1) Column (i) presents estimates of a Probit model using a measure of whether turnover is viewed as too high as the dependent variable; column (ii) presents estimates of a Probit model using a measure of whether turnover is viewed as too low as the dependent variable; column (iii) presents results of Ordered Probit estimates of equation (11), estimated by STATA; standard errors are in parentheses; (\*) indicates statistical significance at the 5% level.
- 2) See the text and the Data Appendix for definitions and sources of variables used.
- 3)  $H_H$  is the test statistic for the hypothesis that the parameters of columns (i) and (iii) are equal;  $H_L$  is the test statistic for the hypothesis that the parameters of columns (i) and (iii) sum to zero; H is the joint test statistic for both hypotheses. See the text for details.



**Table 3****Estimates of  $q_H$  and  $q_L$** **(a) Averages for all Establishments**

	Probit	Probit	Ordered Probit
	Table 2 Col (i)	Table 2 Col (i)	Table 2 Col (iii)
$q_L$		1.70 (1.02)	2.63 (0.84)
$q_H$	21.17 (9.51)		34.72 (11.19)

**(b) Averages across Explanatory Variables  
(Probit Estimates)**

	Train 7 days or more	Hiring difficulty	Works council	Informal communication
$q_L$	1.83 (1.30)	1.59 (0.89)	1.87 (1.07)	1.84 (1.05)
$q_H$	15.73 (6.23)	18.48 (7.41)	16.97 (6.70)	22.10 (9.90)

Notes:

- (1) The table presents means and standard deviations of bounds to optimal turnover rates, calculated by using estimates in columns (i) and (ii) of table 2 in equations (13.1) and (13.2).

## Data Appendix

### Dependent variable:

We analyse responses by managers to the question:

*Is the rate of turnover too high, too low or about right?*

Source: question B2 of EMSPS.

### Explanatory variables:

*Turnover rate:*

*Taking the establishment's workforce as a whole, what was the percentage rate of turnover of employees for the past 12 months?* as explained in the main text.

Source: question B1 of EMSPS.

*Hiring rate:*

For each of nine distinct occupational groups, managers are asked the number of jobs filled in the last 12 months. We add these figures to give total hires and divide this by total employment to give a measure of the hiring rate. This is an imperfect measure as we only have employment data for the previous year.

Source: question C3 of EMSPS.

*Train  $\geq 7$  day:*

For each of nine distinct occupational groups, managers are asked: *How many days are usually involved in initial instruction?* If this is greater than 7 days for any group, the variable is given a value of 1; if not, it has a value of 0.

Source: question D5 of EMSPS.

*Hiring difficulties:*

For each of nine distinct occupational groups, managers are asked: *How easily have you been able to fill vacancies in each of the following occupational groups in the last 12 months?* Responses are on a 1-5 scale (where a response of 1 indicates no difficulty was experienced). We define an establishment as facing a *hiring difficulty* if there is a response in the range 3-5 for any occupational group. Haskel and Martin (2000) analyse this variable in more detail.

*Computer-aided design:* a dummy variable indicating establishments where “the establishment uses microelectronics in design”

Source: question A26 of the Managers Questionnaire of WIRS.

*Word processing:* a dummy variable indicating establishments where “the establishment uses microelectronics in word-processing”.

Source: question A26 of the Managers Questionnaire of WIRS.

*High-tech:* a dummy variable indicating establishments where any new product has used “microprocessors or other microelectronic components” or “new materials such as advanced alloys or engineering plastics” in the production process.

Source: questions G14 and G15 of EMSPS.

*New plant and machinery:* a dummy variable indicating establishments where “new plant and machinery” has been introduced in the previous 12 months.

Source: question A15 of EMSPS.

*New computer applications:* a dummy variable indicating establishments where “new computer applications” has been introduced in the previous 12 months.

Source: question A15 of EMSPS.

*% skilled*: the % of employees who are skilled.

Source: question 3 of the Basic Workforce Data Sheet of WIRS.

*% manuals*: the % of employees who are manual.

Source: question 1 of the Basic Workforce Data Sheet of WIRS.

*%part-timers*: the % of employees who are part-timers.

Source: question 1 of the Basic Workforce Data Sheet of WIRS.

*% female*: the % of employees who are female.

Source: question 1 of the Basic Workforce Data Sheet of WIRS.

*% short-term*: the % of employees who are on short-term contracts.

Source: question N23 of the Managers Questionnaire of WIRS.

*Works council*: a dummy variable indicating the presence of "any joint committees of managers and employees primarily concerned with consultation rather than negotiation.

Source: question L1 of the Managers Questionnaire of WIRS.

*Negotiate working conditions*: a dummy variable indicating managers who negotiate with unions on the issue of working conditions.

Source: question D32 of the Managers Questionnaire of WIRS.

*Informal communication*: a dummy variable indicating the presence of quality circles or regular briefings

Source: question L6 of the Managers Questionnaire of WIRS.

*Log relative wage*: this is calculated as the log wage at the establishment less the log regional wage. The log wage at the establishment is calculated as the log of the wage reported for the typical worker in the group indicated. The log regional wage is the log of the average wage in the relevant region for the specified occupational group.

Source: authors calculations based on question K15 of the Managers Questionnaire of WIRS.

*Local unemployment rate*: the unemployment rate in the travel-to-work area in 1990

Source: 1990 WIRS, extra information.

*Employment*: total employment reported by the establishment in the WIRS survey.

Source: question N23 of the Managers Questionnaire of WIRS.

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