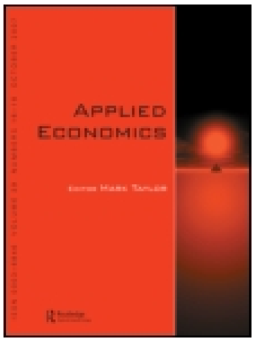

Applied Economics

ISSN: 0003-6846 (Print) 1466-4283 (Online) Journal homepage: http://www.tandfonline.com/loi/raec20

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To cite this article: Pekka Ilmakunnas & Mika Maliranta (2005) Worker inflow, outflow, and churning, Applied Economics, 37:10, 1115-1133, DOI: 10.1080/00036840500109621

To link to this article: https://doi.org/10.1080/00036840500109621

Published online: 16 Aug 2006.

Applied Economics, 2005, **37**, 1115–1133

Worker inflow, outflow, and churning

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Linked employer–employee data from Finnish business sector is used in analysing worker turnover. The data set is an unbalanced panel with over 219 000 observations in 1991–97. The churning (excess worker turnover), worker inflow, and worker outflow rates are explained by plant and employee characteristics. The probabilities of observing non-zero churning, inflow, and outflow rates increase with plant size. The magnitudes of the non-zero churning and inflow rates depend positively on size, but the magnitude of outflow rate depends negatively on size. High-wage plants have low turnover; plants with large within-plant variation in wages have high turnover. Average tenure of employees has a negative impact on turnover. High plant employment growth increases churning and separation but reduces hiring in the next year. Also controlled are average age and education of employees, shares of women and homeowners among employees, foreign ownership, ownership changes, and regional unemployment.

I. Introduction

The worker turnover process is important for many reasons. From the point of view of an individual, quitting a job may give a chance to move to a better job, but involuntary separation may lead to unemployment. From the point of view of the firms, there are hiring and firing costs, which may be explicit monetary costs or indirect disruption of the production process. On the other hand, worker turnover may be productivity enhancing, since the firms can renew their workforce through hiring and separation. From the macroperspective, worker turnover is part of the process through which resources are reallocated from declining to growing firms and sectors and thereby contributes to aggregate growth and productivity.

Empirical analysis of worker turnover has long traditions both in economics and human resource management literature.[1] Research has been conducted using aggregate time series, industry cross-section or panel data, longitudinal data on individuals, and firm or plant panel data. Since the late 1980s there has been much emphasis also on the analysis of job turnover, following the increased availability of large firm or plant data sets. Recent research has examined the two types of turnover together at the plant level to obtain more information on the dynamics of the labour market (Burgess *et al*., 2000a). In this case, one of the issues has been the extent and causes of

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[1] In economics, Parsons (1977, 1986), Farber (1999), and Davis and Haltiwanger (1999) survey the turnover literature from different angles. For the analysis of turnover in the human resource management literature, see Cotton and Tutle (1986) and Griffeth *et al*. (2000).

Applied Economics ISSN 0003–6846 print/ISSN 1466–4283 online © 2005 Taylor & Francis Group Ltd
http://www.tandf.co.uk/journals
DOI: 10.1080/00036840500109621

excess worker turnover, or churning. This is the worker turnover that is not needed to achieve a given job turnover. It is caused by worker outflow that has to be compensated by replacement hiring. Ideally, the analysis should be based on data sets that include information both on firms or plants and on their employees.

In this paper we use linked employer–employee data from Finland (Finnish Longitudinal Employer–Employee Data, FLEED) to examine plant-level flows and their determinants. We are interested in finding out whether there are differences across plants in worker turnover, i.e. what kinds of plants have high hiring and separation rates and high 'excessive' turnover, or churning. We estimate models both for the incidence of turnover and the magnitude of the gross worker flows. They are explained by the characteristics of the plants and their employees. We also examine the cyclicality of the worker flows at the plant level.[2] Finally, we compare different estimation approaches, OLS versus Tobit type models, and weighted versus unweighted estimation.

Finland is an ideal test ground for theories of turnover and their cyclicality. First of all, there are extensive registers of individuals and plants that can be combined to a data set that includes extensive information of the plants and their workforce. Secondly, cyclical changes in the Finnish economy have been very strong in the 1990s (Honkapohja and Koskela, 1999). The end of the 1980s was a period of rapid growth and overheating of the Finnish economy. At the beginning of the 1990s this was followed by a period of very deep recession. The unemployment rate rose rapidly in a few years from 3 to 17%, reaching its peak in 1994. With economic recovery the unemployment rate started to drop slowly thereafter. Our data period covers the whole cycle.

We start with the definitions of the flow measures in Section II. We present a simple model of a firm's decision on hiring and firing in Section III and discuss the implications of the model and previous literature in Section IV. We describe the data and the econometric approach in Section V and examine empirically the influence of various variables on the worker flows in Section VI. Section VII concludes the paper.

II. Flow Measures

Our main source of data on employees is the Employment Statistics, which covers practically the whole working age population in Finland. It can be linked to plant data from other registers. (See the Appendix for a description of the data.) The data are such that we know the identity of all the employees in each plant at the end of the year. The worker flows are therefore discrete measures that are based on a comparison of the employees at the end of two consecutive years. Worker inflow or hiring is defined as the sum of new employees in all plants. Dividing the worker inflow in period t by the average employment in years t and $t-1$, we obtain the worker inflow rate or hiring rate $WIF_t = \Sigma_i H_{it}/(\Sigma_i(L_{it} + L_{i,t-1})/2)$, where H_{it} denotes hiring and L_{it} employment in plant i in year t. Correspondingly, worker outflow or separation is the sum of employees that have left their place of employment. The worker outflow rate or separation rate $WOF_t = \Sigma_i S_{it}/(\Sigma_i(L_{it} + L_{i,t-1})/2)$, where S_{it} is the number of workers that have left plant i in year t. The difference of the inflow and outflow rates is the net rate of change of employment, $NET_t = WIF_t - WOF_t$, and their sum is the worker flow rate or worker turnover rate, $WF_t = WIF_t + WOF_t$. In addition to these measures, it is also possible to decompose H and S by source and destination. We can calculate, for example, the inflow rate of workers to plants from unemployment, $WIFU$, and the outflow rate from plants to unemployment, $WOFU$. We analyse these unemployment related flows in Ilmakunnas and Maliranta (2004).

Job flows are defined following Davis and Haltiwanger (1999). Job creation is the sum of positive employment changes in plants. The corresponding job creation rate is obtained by dividing this figure by the average number of employees, $JC_t = \Sigma_i \Delta L_{it}^+/(\Sigma_i(L_{it} + L_{i,t-1})/2)$, where the superscript '+' refers to positive changes. The job destruction rate is defined as the sum of absolute values of negative employment changes, divided by the average number of employees, $JD_t = \Sigma_i|\Delta L_{it}^-|/(\Sigma_i(L_{it} + L_{i,t-1})/2)$, where the superscript '−' refers to negative changes. The net rate of change of employment or the job flow rate is the difference of these values, $NET_t = JC_t - JD_t$. The sum of the job creation and destruction rates is the gross job reallocation rate, also called the job turnover rate or absolute job flow rate, $JR_t = JC_t + JD_t$, and the difference of the job reallocation rate and absolute value of net change is the excess job reallocation rate, $EJR_t = JR_t - |NET_t|$. The absolute value $|NET_t|$ is the reallocation of jobs that is at least needed for achieving net employment change NET_t. The reallocation that exceeds this is

[2] We analyse the cyclical behaviour of the gross job and worker flows at the aggregate level and in main industries in a separate paper (Ilmakunnas and Maliranta, 2003).

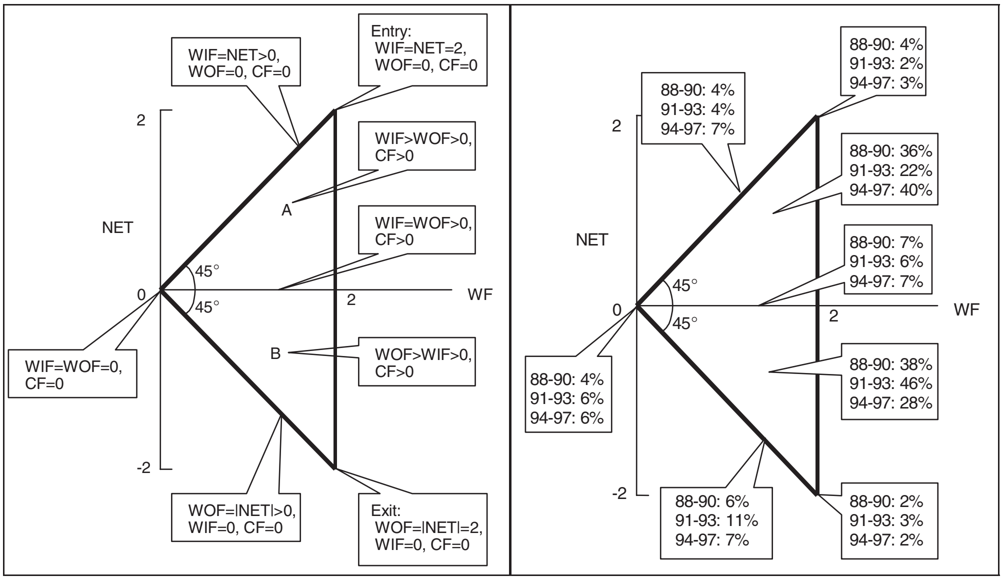

Fig. 1. The flow regimes at the plant level (left) and employment shares of the flow regimes in 1988–1990, 1991–1993 and 1994–1997 (right)

'excessive'. The difference of the worker turnover and job turnover rates is the churning flow rate, $CF_t = WF_t - JR_t$ (Burgess *et al.*, 2000a)[3], so that the worker flow can be decomposed as $WF_t = CF_t + EJR_t + |NET_t|$. JR_t is the amount of worker turnover that is at least needed, since growing plants need more workers and declining plants have outflow of workers. Since there is also outflow of workers from continuing positions and corresponding replacement hiring, the part of worker turnover that exceeds JR_t is 'excessive'.

Following Davis *et al.* (1996), all the flows are divided by the average of period t and $t-1$ employment. Because of this scaling, all gross flow rates can in principle vary in the interval $[0, 2]$ ($[0, 200\%]$) and the net change in the interval $[-2, 2]$ ($[-200\%, 200\%]$). Note that short spells of employment within the year cannot be observed. If they were, the worker flow rates could exceed 2 (200%). Although our data therefore do not enable us to observe the worker flows continuously, the advantage of the discretely measured flow is that it is comparable to the discretely measured job turnover. In particular, since the job and worker flows are based on the same data, it holds consistently that $NET_t = JC_t - JD_t = WIF_t - WOF_t$.

At the plant level the connections between the flow measures can be illustrated with the triangle in the left-hand panel of Fig. 1.[4] (In the remainder of the paper, we present for simplicity all plant level flow rates without plant subscript i or time subscript t.) The vertical axis measures the net change of employment in the plant, NET, and the horizontal axis the worker turnover rate, WF. At the plant level, $|NET|$ also measures the job creation or destruction rate. For a growing plant, $NET > 0$ and $JC = JR = NET$, so that job turnover is only job creation. Therefore at the plant level, the excess job reallocation rate $EJR = 0$. For a shrinking plant, $NET < 0$, $JD = JR = |NET|$, and job turnover is only job destruction. Because $WF \geq |NET|$, all plants have to be situated in a triangle that is bordered by two lines, one of which has slope 1 (upward sloping 45 degree line), and the other has slope -1 (downward sloping 45 degree line). The third side of the triangle is a vertical line at $WF = 2$ (200%). Along the upward sloping 45 degree line the worker outflow rate $WOF = 0$ and $NET = WIF = WF$, so that all of worker turnover comes from inflow. In the area between the upward sloping line and the horizontal axis the plant is growing, $NET > 0$, but it has simultaneous worker inflow and outflow, $WIF > WOF > 0$. Along the horizontal axis the plant does not grow, $NET = 0$, and inflow and outflow are equal, $WIF = WOF$. Along the downward sloping 45 degree line, the worker inflow rate $WIF = 0$, $|NET| = WOF = WF$ and all of worker

[3] A measure that equals CF/2 is called replacement rate by Albæk and Sorensen (1998) and excess turnover by Barth and Dale-Olsen (1999).

[4] The idea of this triangle is adopted from Burgess *et al.* (2000a). In Ilmakunnas and Maliranta (2000) we present the distribution of Finnish manufacturing plants in the triangle.

turnover is caused by outflow. In the area between the downward sloping line and the horizontal axis, the plant is shrinking, $NET < 0$, but it has simultaneous worker inflow and outflow, $WOF > WIF > 0$.

Point A in the figure represents a plant, whose vertical distance to the horizontal axis is net change NET, which in this case is also equal to the job creation rate JC and job turnover rate JR. The horizontal distance of point A to the upward sloping line is therefore the difference of the worker turnover rate WF and job turnover rate JR, i.e. the churning rate CF. Point B represents a shrinking plant, whose vertical distance to the horizontal axis is now the job destruction rate JD and job turnover rate JR. The horizontal distance of point B to the downward sloping line is again the churning rate CF. At the plant level[5] $CF = 2^*\min(WIF, WOF)$. When $NET > 0$, $CF = WIF + WOF - (WIF - WOF) = 2^*WOF$, when $NET < 0$, $CF = WIF + WOF - (-(WIF - WOF)) = 2^*WIF$, and when $NET = 0$, $CF = WIF + WOF = 2^*WIF = 2^*WOF$. By definition, excess worker turnover, or churning, can appear only in three cases: declining plants that have hired workers, growing plants that have had separations, and plants with $NET = 0$, but equal hiring and separation rates. In the last group all of worker turnover is excessive, and $CF = WF$.

When $NET = 2$ (200%), $WIF = WF = 2$ (200%), and $WOF = 0$, the plant is entering. When $NET = -2$ (−200%), $WOF = WF = 2$ (200%), and $WIF = 0$, the plant is exiting. In addition, along the vertical line where $WF = 2$ (200%), the whole personnel of the plant changes during the year.

To give an impression of the importance and cyclicality of the different flow regimes, the right-hand panel of Fig. 1 shows the employment shares of the plants in the Finnish business sector in the regimes in three time periods. The years 1988–1990 were a boom period, the period 1991–1993 was the deepest recession, and the years 1994–1997 were a period of recovery. The shares have been calculated from data on over 100 000 business sector plants each year. Entering and exiting plants are typically small and account for only a few percent of total business sector employment, although their share of the number of plants is higher.[6] The average employment share of exiting plants has been 2–3% and that of entering plants 2–4%. The continuing plants that have declined and not hired new workers had 11% of the workforce in the business sector during the recession and 6–7% in the other periods. The plants that have declined, but still have hired some new workers have experienced big changes in their employment share. They had 38% of employment in 1988–1990, but 46% during the recession and 28% in recovery. The plants that have not grown and have had no turnover in their workforce, i.e. point (0,0), has had an employment share of 4–6%. The plants that have had some turnover among the workers, but equal inflow and outflow, i.e. those on the horizontal axis, have had 6–7% of the business sector employment. The employment share of growing plants that have had some separations has varied widely. It decreased from 36% in 1988–1990 to 22% in 1991–1993, and increased again to 40% in 1994–1997. In the plants that have had only inflow of workers, the employment share was 7% during the recovery and 4% in the other periods. All in all, the figures show that in the 1990s three-quarters of the business sector employees were in plants that had some churning. It is clearly a phenomenon that deserves attention.

III. A Model of Hiring and Firing

In order to put the flow measures in the perspective of relevant economic theory, we present a simple model of labour demand. Various characteristics of the plants and their employees can be assumed to affect the parameters of the models. We therefore also summarize what we expect the relationships to be in light of the literature in the field.

We start with an adjustment cost model of labour demand, where hiring and separation and costs related to them are separately analysed. Assume for simplicity that the firm has a single input, labour L_t (subscript t denotes the time period), which is used in the production function $Y_t = AL_t^\alpha$, where $\alpha < 1$. Denote the number of workers quitting Q_t, those

[5] Previously, Oi (1962) used the minimum of separations and hirings as a measure of replacement hiring, using aggregate (industry-level) data. However, the result discussed in the text needs not hold at the aggregate level (or for a group of plants) where there is simultaneous job creation and destruction. Instead, at the aggregate level it holds that $CF + EJR = 2^*\min(WIF, WOF)$. Hence, Oi's measure includes, besides genuine replacement hiring or churning, also excess job reallocation across firms in the industries.

[6] For example in manufacturing, the exiting plants accounted for 16% and the entering plants for 10% of the total number of plants during the recession years (Ilmakunnas and Maliranta, 2000). We have interpreted as an exited plant such a plant that was in the register in year $t-1$, but no longer in year t. Besides true exit, there may be other reasons why a plant disappears from the registers, but plant data is much less problematic in this sense than firm data that may be influenced, for example, by mergers.

hired H_t, and those fired F_t. The corresponding quit, hiring, and firing rates are $q_t = Q_t/L_{t-1}$, $h_t = H_t/L_{t-1}$, and $f_t = F_t/L_{t-1}$ respectively. For simplicity, we define the rates here as flows of workers divided by the previous period's employment. The labour costs consist of wage cost w_t and labour adjustment costs that are related to recruitment, training and layoff costs. The firm takes the wage as given, either because of competitive labour markets or wage set by a monopoly union. The hiring and firing costs are assumed to have the following forms: $a_H h_t L_{t-1}$ and $a_F f_t L_{t-1}$, respectively. These are based on the assumptions that the costs are linear in the number of employees hired or fired. Note that since we assume so far that the labour input is homogeneous, the firm does not hire and fire at the same time. However, there can be simultaneous inflow and outflow of workers, since there can be voluntary quitting and replacement hiring at the same time. The firm is either in a hiring regime, a firing regime, or in an inaction regime.

Introducing dynamic optimization and forward-looking behaviour we could easily derive a model with dynamics. However, since our purpose is not to estimate the following equations directly, for illustrative purposes it suffices to assume that the firm does not optimize over time. The firm chooses h_t and f_t to maximize profits

$$\pi_t = p_t A L_t^{\alpha} - w_t L_t - a_H h_t L_{t-1} - a_F f_t L_{t-1} \quad (1)$$

Subject to the accumulation of labour input

$$L_t = (1 - q_t)L_{t-1} + h_t L_{t-1} - f_t L_{t-1} \quad (2)$$

and $h_t \geq 0$, $f_t \geq 0$. In the hiring regime, $f_t = 0$ and hiring is determined by maximizing (1) with respect to h_t taking into account (2):

$$\frac{\partial \pi_t}{\partial h_t} = \alpha p_t A L_t^{\alpha-1} L_{t-1} - w_t L_{t-1} - a_H L_{t-1} = 0 \quad (3)$$

Using Equation 2 and solving for h_t we obtain

$$h_t = -(1 - q_t) + [(w_t + a_H)/\alpha p_t A]^{1/(\alpha-1)}/L_{t-1} \quad (4)$$

Multiplying by L_{t-1} and dividing by $\bar{L}_t = (L_t + L_{t-1})/2$ we obtain the worker inflow rate WIF (as defined above in Section II)

$$WIF_t = -(1 - q_t)L_{t-1}/\bar{L}_t + [(w_t + a_H)/\alpha p_t A]^{1/(\alpha-1)}/\bar{L}_t \quad (5)$$

The worker outflow rate will be determined by the quit rate as

$$WOF_t = q_t L_{t-1}/\bar{L}_t \quad (6)$$

The churning rate is in this case equal to the minimum of WIF and WOF, i.e. if $WIF > WOF$, only the amount of quits is replacement hiring and the rest of hiring goes to increase the workforce of the firm. If $WOF > WIF$, all hiring is replacement hiring, but it does not suffice to maintain the workforce.

In the inaction regime both $h_t = 0$ and $f_t = 0$. The inflow rate is now zero, the outflow rate (6) is determined by quits, and churning is zero. The outflow will never be zero in our simple model, since we have assumed a constant quit rate. Finally, in the firing regime, $h_t = 0$ and firing is determined by the condition

$$\frac{\partial \pi_t}{\partial f_t} = -\alpha p_t A L_t^{\alpha-1} L_{t-1} + w_t L_{t-1} - a_F L_{t-1} = 0 \quad (7)$$

Proceeding the same way as above, we obtain the firing rate as

$$f_t = (1 - q_t) - [(w_t - a_F)/\alpha p_t A]^{1/(\alpha-1)}/L_{t-1} \quad (8)$$

and the total outflow rate is the sum of quit and firing rates (multiplied by $L_{t-1}/\bar{L}_t$)

$$\begin{aligned} WOF_t &= q_t L_{t-1}/\bar{L}_t + (1 - q_t)L_{t-1}/\bar{L}_t \\ &\quad - [(w_t - a_F)/\alpha p_t A]^{1/(\alpha-1)}/\bar{L}_t \\ &= L_{t-1}/\bar{L}_t - [(w_t - a_F)/\alpha p_t A]^{1/(\alpha-1)}/\bar{L}_t \quad (9) \end{aligned}$$

In this case the inflow rate WIF is zero and also the churning rate is zero.

In the simple model presented above, we can conclude that the hiring (and inflow) rate is positively related to the quit rate q_t (and factors that influence it positively), demand shocks that may increase price p_t, and productivity parameters A and α, and negatively related to wage w_t and the hiring cost parameter a_H. The firing rate, in turn, has a negative relationship to the quit rate, price, the firing cost parameter a_F, and the productivity parameters, and a positive relationship to wage. Note that the quit rate cancels out of the expression for the outflow rate, since voluntary quits always reduce the need for firing by the same amount.

In a forward-looking model the firm would have to take into account the possibility that a hiring regime may be followed by a firing regime and a firing regime by a hiring regime. Therefore, also future firing costs would have an impact on present hiring and future hiring costs on present firing.

To have simultaneous hiring and firing, we could extend the model by including two types of labour L_1 and L_2 in the production function $Y_t = A L_{1t}^{\alpha} L_{2t}^{\beta}$, with different wage rates and adjustment (hiring and firing) costs. The firm then has four choice variables, two hiring rates and two firing rates. Now it is possible that the number of workers of one type is decreased through firing at the same time when the other worker type is in the hiring regime.

The simple model assumes a competitive labour market, where the firm takes the wage as given. In recent years, there has been a surge of labour market research based on monopsonistic markets, where the firms set wages (Manning, 2003). Even in the presence of a unionized labour market, a floor to wage is set by bargaining with a union, but the firm can pay a higher wage. We could extend the above model by assuming that the quit rate depends negatively on wage, as in the efficiency wage models (Salop, 1979). It can be assumed that this kind of quit rate function reflects search behaviour of the employees (Burdett, 1978) and/or the process by which matches are broken (Jovanovic, 1979). In search models quit is the worker's decision based on the probability of job offers and the distribution of wages. In matching models workers stay in matches with high productivity and wage, whereas low wage workers quit. In this extension the firm would have two choice variables, wage and hiring rate (or firing rate in the firing regime).[7] The hiring rate is still negatively related to wage, since wage is used for reducing quits and thereby the need for replacement hiring. However, the wage is now endogenous.

IV. Predictions from the Theory and Previous Empirical Work

One implication of the above model is that if the firm takes wage as given, wage should be negatively related to the inflow rate and positively to the outflow rate. In the wage-setting model the same holds, but wage is endogenous. Because outflow through quits causes replacement hiring, also the churning rate should be negatively related to wage.

The simple model above has the same wage for all workers. However, besides the level of wage, also its variation over the tenure or across workers may have implications for turnover. If human capital is at least partly general, wage growth within a job decreases the likelihood of separation (Munasinghe, 2000). This implies that the steepness of the wage profile is a determinant of turnover. For completely firm-specific human capital, the outside opportunities of the workers shrink and the wage needs not rise as fast since the quit rate lowers in any case. Some researchers have tested the implications of the wage profile by estimating wage equations for each firm and explaining turnover by the firm-specific slopes of the wage equations, i.e. coefficients of education and experience (Leonard *et al*., 1999; Barth and Dale-Olsen, 1999). However, this requires enough worker observations in each plant or firm and therefore would leave out smaller firms.

The intra-firm variability of wages is sometimes used as a proxy for seniority-based wage setting. Powell *et al*. (1994) use the variance of wage equation residual, and Galizzi and Lang (1998) use an individual's wage relative to the within-plant average wage for similar workers as an indication of future wage growth potential. Haltiwanger and Vodopivec (2003) use within-firm wage dispersion to explain churning. They argue that wage dispersion will increase churning in poor matches and decrease it in good matches, leaving the net effect on total churning uncertain.

The relationship between wage variation and turnover may also have other interpretations. Wage dispersion within plants can reflect heterogeneity in the productivity of the workers. Firms try to raid the best workers from the other firms (Lazear, 1986). Workers who get offers from competing firms are those who are known to be highly productive and already receive high wages. Those who stay are from the bottom of the productivity and wage distribution. Therefore high wage dispersion and high turnover can coexist. When there is uncertainty about worker types, wage dispersion is low and competitors have less incentive for making offers to workers who may turn out to have low productivity. One would therefore expect that turnover is lowest when average wage is high, but wage dispersion low since then both quits and raiding are low. Low wage dispersion may also reflect the workers' preferences for equality and 'just' wages. Workers who feel that the high wage differences are 'unjust' may be more inclined to quit (Telly *et al*., 1971; Galizzi, 2001). Considering the diverse views summarized above, the relationship between wage variation and worker flows is uncertain *a priori*.

Next, we turn to factors that may influence the quit propensity of the employees besides wage. Considerable attention in the literature has received the relationship between tenure and separations (Farber, 1999). An individual's probability of switching jobs typically decreases with tenure; i.e. separation has negative state dependence. Further, since those workers that are prone to switch jobs, do it early, also worker heterogeneity leads to a negative relationship between average tenure and turnover, even if the separation probability for each individual were constant over time. In the matching models the

[7] In wage-setting models the distinction between quits and firing need not be essential. The efficient turnover hypothesis argues that in principle quits and layoffs are equivalent from the point of view of both parties. When the firm rejects a wage demand, the worker quits, and when a worker rejects a wage cut, he is laid off (McLaughlin, 1991).

survival of good matches induces a negative relationship between the length of tenure and separation rate. In search models, the length of tenure indicates that there has been longer on-the-job search and hence the current job has the best wage and there is little incentive to switch and search intensity falls with tenure. On the other hand, if one takes into account that the increase in wage within the current job slows down with tenure, the transition rate to new jobs may actually increase with tenure, conditionally on wage (Mortensen, 1988). Overall, we expect average tenure in a plant to have a negative influence on the outflow and churning rates. With plant-level data it is difficult to distinguish between negative state dependence and worker heterogeneity as the sources of the negative correlation between average tenure and turnover. It is, however, possible to control for worker heterogeneity by using various plant-level measures of workforce characteristics. As for worker inflow, it is obvious that plants with high-tenure workforce have low inflow rates.

For women, the matching process may be more constrained than for men because of family, and they may be less mobile than men. The share of female employees would then be negatively related to a plant's churning rate. A counter-argument is that women have more career interruptions, which is reflected in higher turnover among workers that are in childbearing age, at least if maternity leave is defined as a separation. Further, because of career interruptions, women accumulate less human capital and have lower wage, which could increase their willingness to switch jobs (Royalty, 1998). The impact of the share of female employees on the flow rates is therefore unclear.

There are potential negative effects of home ownership on the mobility of labour (Oswald, 1996). A lower quit rate of workers who are tied to a certain location by home ownership should therefore be reflected in a negative relationship between plant-level churning rates and the share of workers who own their home. We therefore expect the share of home-owners to have a negative influence on outflow and churning. Naturally, there can also be such a selection mechanism that workers who dislike job switches tend to buy their own home.

Also the age of the workforce may be related to turnover. Young persons are less attached to a particular location and are likely to be more willing to move. They may also have more to gain from search since their information on different types of jobs is likely to be more limited. The age composition of the plant's workforce may thus be an important explanatory variable. We expect outflow and churning rates to decline with average age of employees. If age of employees is correlated with plant age, it is also likely that plants with young employees grow faster and thereby have higher worker inflow rates. If plant age is separately controlled, one could expect this effect to be smaller.

Education is a characteristic of workers that may have a strong influence on their turnover. Typically educated workers have better chances of finding employment elsewhere, since their skills are adaptable to various tasks. This is likely to increase their quits compared to the less educated workforce. Since quits lead to replacement hiring, both the outflow and churning rates of plants with educated workers should be higher than those of plants with a less educated workforce. On the other hand, there are opposite influences. The layoff rate of educated employees may be lower, if skills are firm specific and education increases the adoption of skills on-the-job or educated workers receive more training (Neal, 1998). This creates adjustment costs for the firm and mobility costs for the employee and lowers quits and layoffs. The combined effect of these opposite effects may be a positive or a U-shaped relationship between outflow and education.

Various plant characteristics may describe the technology of the plant, its adjustment costs, and prospects for demand growth. In firms that have grown in the past the need to hire lots of new workers may have led to a deterioration of the quality of the matches. This can show up later as increasing separations and excessive turnover (Burgess *et al.*, 2000a, b). Also in declining firms, layoffs may give rise to more quits if workers see their future prospect bleak. Therefore, also past job destruction may lead to excessive turnover. We therefore expect that past employment growth has a positive impact on the outflow and churning rates.[8] There has also been discussion on the consequences of ownership changes on employment growth (McGuckin and Nguyen, 2001) and also worker flows may be affected. Reorganization after ownership change may slow down hiring and increase worker outflow through firing or voluntary job switches.

There is evidence that plant age and size affect excess turnover (Lane *et al.*, 1996; Burgess *et al.*,

[8] The turnover of personnel may coincide with changes in the technology of the firm, i.e. investment in new technology may cause exit of some old workers and entry of new ones that have skills appropriate for the new equipment (Bellman and Boeri, 1998; Maliranta, 2000).

2000b). This may be related to the development of the matching process over time as the plant ages, and to returns to scale in the screening of new workers. Therefore we can expect that the churning rate is lower in older and larger plants. It is also possible that larger plants can offer non-wage benefits that decrease worker turnover. If workers in young and small plants are more prone to look for promotion possibilities in other plants, the outflow rate should be lower in large plants. If small and young plants grow faster (Sutton, 1997), their inflow rates can be expected to be high. Controlling for growth should diminish this effect, but there may still be relatively high hiring rates in new firms if the hiring decisions are based on future prospects.

According to the model presented above, productivity (parameter A) should have a positive impact on worker inflow and a negative one on worker outflow, i.e. high productivity plants should grow faster. In practice, the relationship may be more complicated, since high worker outflow and low worker inflow rate may be the way in which plants maintain their productive advantage.

Finally, quit rates tend to be strongly procyclical, whereas layoffs are less strongly countercyclical, making total separations procyclical (Akerlof *et al.*, 1988; Parsons, 1977). The cyclical situation can affect turnover in search models through the probability of finding a new job, which varies over the business cycle. Naturally, hiring varies procyclically as firms hire new workers in cyclical upturns. Since demand and the prospects for finding new jobs are likely to vary regionally and by industry, we can also expect to see regional and industry effects in the flows.

V. Data and Econometric Approach

Our main source of data on worker flows and worker characteristics in Finland is the Employment Statistics, and on plant characteristics the Business Register, which can be linked at the plant level. We concentrate on the business sector in the period 1991–1997, i.e. we mainly exclude agriculture and the public sector (see the Appendix for a description of the data and a definition of the business sector). The data from 1988–1990 is excluded because it is somewhat less reliable (Ilmakunnas and Maliranta, 2003). When plants with missing data on some of the variables are excluded, we are left with an unbalanced panel with over 219 000 plant-year observations.

To examine the influence of various plant and worker characteristics on the worker flow rates, we have estimated models for churning CF, inflow WIF, and outflow WOF. As discussed above, the churning rate CF measures replacement hiring. The outflow rate WOF reflects both quits and job destruction through layoffs. The inflow rate WIF, in turn, is a combination of replacement hiring and job creation. We cannot identify quits and layoffs separately, but it can be argued that most of the outflow to unemployment is involuntary.[9] In this sense we can treat the outflow rate to unemployment $WOFU$ as a lower limit to the layoff rate. The rate of outflow that does not result in unemployment, $WOF - WOFU$ consists of both quits and layoffs which have resulted in a new job within the year or withdrawal from the labour market. We could use it as an approximation of the quit rate. We do not present results on this measure of quits, but briefly comment on some estimations made.[10] Our analysis concentrates on worker flows and we do not examine plant-level job creation and destruction in this paper. At the plant level these job flow rates are simply absolute values of the net rate of employment change NET.[11]

The worker flow rates are in the interval $[0, 2]$, and there are many observations that are either 0 or 2. On the other hand, we have used in the estimations only continuing plants, i.e., in each year we use only the plants that have existed in that year and the previous two years.[12] In this way we avoid problems with the definition of entry and exit. This leaves so few

[9] If quits and layoffs could be identified, the behaviour of the plants could be modelled with hiring and layoff equations, as in Hassink and Broersma (2003), but even then some quits may be initiated by the employer.

[10] We have examined hiring from unemployment and separations to unemployment in a separate paper (Ilmakunnas and Maliranta, 2004).

[11] In principle, observed hiring is not equal to desired hiring, since the plants may have open vacancies that they have not yet been able to fill. (The process of filling vacancies has been examined in several papers, e.g. Gorter *et al.*, 1996; van Ommeren and Russo, 1997). This may underestimate the desired inflow. The nature of vacancies, and hence the characteristics of the plant and its employees, may also affect the success of filling the vacancies (van Ommeren and Russo, 1997). In practice, however, vacancy durations are relatively short compared to our data that is based on end-of-year comparisons. Most outflows during the year would have already led to a replacement hiring. Any open vacancies at the end of the year would have been posted only a few weeks before. Further, it is unlikely that many vacancies would be posted just before the Christmas and New Year season.

[12] The two-year lag arises because we use lagged $NET(-1)$ as an explanatory variable. $NET(-1)$ in turn is calculated by using the average employment in years $t-1$ and $t-2$ as the denominator.

observations for which the flow rates are equal to 2 that we do not treat them as corner solutions. However, there are still fairly many observations that are zeros. For *CF*, 55% of values are zeros, and for *WIF* and *WOF*, the shares are somewhat lower, 41 and 36%, respectively.

Researchers interested in job and worker flows have used various ways of dealing with the distribution of the flow rates. In industry-level analysis there are typically very seldom flow rates that are equal to zero. Therefore a logistic transformation of the flow rates can be used for guaranteeing that the rates are between 0 and 2. If there are some zero observations, they can be handled by including an arbitrary small constant in the transformation. However, this is not feasible in the case of many zero observations, which is common in plant-level data.[13] Another approach sometimes used is the ordinary (type 1) Tobit model, which has the advantage that a high concentration of zeros can be dealt with. On the other hand, it has the disadvantage that the explanatory variables have the same coefficients in the determination of the probability of having a non-zero flow rate and in the determination of the magnitude of the flow rate when it is positive. An obvious example that illustrates this problem is the impact of plant size on the worker flow rates. One can argue that it is likely that plant size has an opposite effect, for example, on the probability of having a positive worker inflow rate and on the magnitude of the inflow rate when it is positive. Because of lumpy adjustment costs a small plant may be hesitant to hire a new worker. However, when a worker is hired, the inflow rate is immediately high and declining with plant size. For example, if one new worker is hired, the inflow rates for plants that initially have 1, 2, 3, or 4 employees are 0.67, 0.40, 0.29, and 0.22, respectively. Since the group of small plants has both many zero and very high flow rates, on average the flow rate of the small plants may be the same as that of the large plants.

To avoid these problems, we use instead type 2 Tobit model. There is a discrete part, a probit model for non-zero flow rates, and a continuous part, a truncated model for positive flow rates. The coefficients of the two parts can differ and their errors are allowed to be correlated. There is no sample selection problem, since when the flow rates are zero, we observe the characteristics of the plant. Rather, the zeroes are genuine corner solutions, since it may be optimal for the plants to have zero hiring or separation rates. This has implications on the interpretations of the results, as will be discussed in the next section.[14] The model is estimated using maximum likelihood including all variables both in the probit and the continuous part. We rely on non-linearity for identification of the model, since on a priori grounds it is difficult to exclude any variables. After all, both parts describe aspects of the same phenomenon. We estimate the Tobit models separately for each of the flow rates.[15]

One problem with the use of Tobit type non-linear models is that the fitted values of *WIF* and *WOF* from the continuous parts of the models do not necessarily satisfy the constraint $NET = WIF - WOF$. If we use OLS estimation, which however, is inconsistent in this case, the constraint would be satisfied. OLS estimates can still be justified on the grounds that they approximate the conditional means of the flow rates when the explanatory variables are close to their mean values (Wooldridge, 2002).

Another issue that we address is the use of weighting. The models are estimated both without weighting and with weighting by plant size (average of current and last year's employment). This is the size used as the denominator in the flow rates. The use of weighted estimation is justified on the grounds that we are interested in estimating effects that describe turnover in total employment. Unweighted estimation would give equal weight to large plants with low flow rates and small plants that have high flow rates but account for a small share of employment. Another justification for using weights is that the errors may be heteroscedastic with standard deviations inversely proportional to plant size. Note that the weighting essentially removes much of the problem of zero flow rates. Most of them appear in small plants that have low weight in the estimation. As Fig. 1 shows, the employment shares of the plants with $WIF = 0$, $WOF = 0$ and $CF = 0$ have been around 8–14%, 6–10%, and 20–25%, respectively. These figures are much lower than the corresponding

[13] A justification for using the logit transformation is that if at the level of individuals the quit or hiring decisions are based on logit models, the plant-level flow rates can be regarded as grouped data. This leads to a logistic transformation of plant-level flows and heteroscedasticity in the error term (Greene, 2003, pp. 687–8). When the flow rate is in the interval [0,2], it could be transformed to the form $\log((X + c)/(2 - X + c))$, where X is a flow rate and c is a small constant. However, this does not solve the problem of high concentration of zero values. The transformation just shifts the peak to the negative value $\log((c/(2 + c))$.
[14] The same issue of corner solution would arise also in the ordinary Tobit model. There is no censoring, as there cannot be negative censored flow rates.

shares of the number of plants. We would therefore expect that weighted OLS gives results that are close to those from the type 2 Tobit model.

We use most of the explanatory variables in categorical form, so that for example plant size is defined by five groups, from the smallest (group 1) to the largest (group 5). The classification is always from the lowest/smallest to the highest/largest, with the exception that in the case of plant age it is from the oldest (group 1) to the youngest (group 5). The reference group of the categorical variables is group 1. The groups are defined at the two-digit industry level for each industry separately in each year, so that the employment shares of the groups are 20%. The categorical variables can track possible nonlinearities in the relationships. Note that a plant can in principle be classified to different groups in different years, although in most cases the classifications are fairly stable. In this sense the variables are measuring the plant fixed effects. To reduce problems with simultaneity of the variables (e.g. the simultaneity of wage, tenure, and separations), we base the classifications on year $t-1$ values, whereas the flow rates are based on comparison of years t and $t-1$.[16]

We report estimation results for the following 5-group categorical explanatory variables that describe plant characteristics: plant size (two-year average employment), plant age, average wage level, coefficient of variation (CV) of wages within the plant, sales/employee, and average years of tenure (plant-specific experience) of the employees. Sales/employee is a proxy for productivity. For manufacturing we could obtain a better measure of productivity from the Industrial Statistics. However, since we analyse a broad range of industries, we have to rely on this proxy. Since the plants are classified in each industry separately, we can take into account the fact that the relationship between sales and value added varies from industry to industry. To take into account the dynamics of the worker flows we include as a continuous variable $NET(t-1)$, the net employment change of the plant in the previous period.

In addition to these variables, we control several other characteristics of the plants and their employees. The coefficients of these variables are not reported, but we briefly comment on some results. As controls, we use the following 5-group categorical variables: average age of employees, average education years, the share of women among employees, and the share of employees that own their own house or apartment. We use a dummy variable for plants that are foreign owned (ownership share over 50%) and also account for changes in ownership. There are two possible changes that are taken into account with dummy variables: change from domestic to foreign, and from foreign to domestic ownership; the reference group is no ownership change. To account for regional differences, we include the unemployment rate of the region where the plant is situated (18 regions) as a continuous variable. All models include year dummies to account for the macroeconomic developments, region dummies, and two-digit industry dummies (54 industries).

VI. Empirical Analysis of Worker Flows

We present the results in the following way. Table 1 shows results for the worker inflow rate from OLS and the continuous part of the type 2 Tobit model. In both cases, weighted and unweighted estimates are shown. The table includes only the main variables of interest, but some comments on the variables that are not shown are made in the text. Tables 2 and 3 show similar results for the worker outflow rate WOF and churning flow rate CF, respectively. Finally, Table 4 shows the estimates of the probit part of the Tobit model for WIF, WOF, and CF. Again both weighted and unweighted estimates are reported. We report robust t-values that also account for correlation of errors within clusters (observations for the same plant).

Interestingly, weighted OLS and weighted Tobit give practically the same result which shows that weighting has indeed made the problem of excessive zeroes much less severe. This actually holds for all of the variables reported here. The difference between the weighted estimates is largest in the case of plant size groups. This is understandable, since plant size (as a continuous variable) was used as the weight. In the Tobit model the estimated coefficients that are reported in the tables are not directly the marginal impacts of the variables. The marginal effect of a

[15] In principle, the models could be estimated as a system, but this would unnecessarily complicate the analysis. See Hassink and Broersma (2003) for an example of joint estimation of Tobit models for hiring and layoffs.

[16] It should be noted that the composition of the workforce in a plant in terms of average age, education etc. is partly determined by the matching process. For example, if young workers have a high tendency to quit, the average age of workers increases. Lagging the variables also reduces problems of this kind of simultaneity of turnover with the workforce characteristics.

Table 1. Models for hiring rate *WIF*

		OLS, unweighted	OLS, weighted	Tobit 2, continuous part, unweighted ML	Tobit 2, continuous part, weighted ML
Plant size	2	0.056***	0.034***	0.079***	0.038***
		(36.568)	(11.028)	(37.113)	(10.235)
	3	0.072***	0.050***	0.113***	0.060***
		(35.517)	(11.934)	(41.186)	(12.216)
	4	0.086***	0.054***	0.143***	0.069***
		(31.181)	(10.476)	(41.036)	(11.573)
	5	0.089***	0.065***	0.160***	0.084***
		(21.787)	(11.111)	(33.416)	(12.784)
Plant age	2	−0.007***	−0.011**	−0.011***	−0.012**
		(3.598)	(2.316)	(3.707)	(2.391)
	3	0.004**	0.005	0.004	0.005
		(2.137)	(0.999)	(1.189)	(0.816)
	4	0.013***	0.017***	0.013***	0.017***
		(6.080)	(3.095)	(4.448)	(2.916)
	5	0.032***	0.043***	0.037***	0.044***
		(14.278)	(7.871)	(11.962)	(7.659)
Average wage	2	−0.008***	−0.011***	−0.010***	−0.011***
		(5.082)	(2.950)	(4.360)	(2.941)
	3	−0.009***	−0.020***	−0.011***	−0.020***
		(5.107)	(4.643)	(4.126)	(4.396)
	4	−0.008***	−0.031***	−0.008***	−0.032***
		(3.990)	(6.185)	(2.877)	(5.941)
	5	−0.001	−0.025***	−0.001	−0.026***
		(0.543)	(4.985)	(0.255)	(4.858)
CV of wage	2	−0.028***	−0.031***	−0.036***	−0.034***
		(18.643)	(7.953)	(16.791)	(7.868)
	3	−0.032***	−0.036***	−0.041***	−0.039***
		(18.125)	(7.961)	(16.372)	(7.994)
	4	−0.034***	−0.033***	−0.041***	−0.035***
		(16.997)	(6.874)	(15.047)	(6.888)
	5	−0.031***	−0.026***	−0.035***	−0.028***
		(14.181)	(5.472)	(11.684)	(5.595)
Sales/employee	2	0.006***	−0.010**	0.011***	−0.010**
		(3.682)	(2.336)	(4.682)	(2.093)
	3	0.007***	−0.022***	0.012***	−0.022***
		(4.059)	(4.659)	(4.881)	(4.428)
	4	0.014***	−0.020***	0.022***	−0.020***
		(7.475)	(4.512)	(8.566)	(4.256)
	5	0.025***	−0.012**	0.035***	−0.011**
		(12.008)	(2.429)	(12.519)	(2.189)
Average tenure	2	−0.059***	−0.043***	−0.077***	−0.047***
		(33.986)	(11.129)	(33.370)	(11.290)
	3	−0.079***	−0.057***	−0.106***	−0.062***
		(40.241)	(12.464)	(39.570)	(12.865)
	4	−0.095***	−0.077***	−0.131***	−0.084***
		(44.447)	(15.578)	(43.642)	(15.913)
	5	−0.096***	−0.083***	−0.140***	−0.093***
		(42.032)	(15.653)	(42.506)	(16.187)
$NET(t-1)$		−0.096***	−0.060***	−0.124***	−0.063***
		(46.251)	(9.531)	(46.629)	(9.562)
N		219351	219351	219351	219351
R^2		0.097	0.147		

Notes: Reference groups: group 1 for each variable. Not reported: average age of employees, average education, share of women, share of homeowners, foreign ownership, ownership change, regional unemployment rate, year, industry, and region dummies, constant. Robust z statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1% level.

Table 2. Models for separation rate *WOF*

		OLS, unweighted	OLS, weighted	Tobit 2, continuous part, unweighted ML	Tobit 2, continuous part, weighted ML
Plant size	2	−0.023***	−0.018***	−0.006***	−0.011***
		(12.567)	(5.601)	(2.583)	(2.963)
	3	−0.033***	−0.019***	−0.004	−0.005
		(13.731)	(4.184)	(1.323)	(1.045)
	4	−0.046***	−0.032***	−0.006	−0.014***
		(14.380)	(6.502)	(1.530)	(2.712)
	5	−0.068***	−0.054***	−0.022***	−0.036***
		(15.456)	(9.806)	(4.446)	(6.316)
Plant age	2	−0.022***	−0.025***	−0.028***	−0.029***
		(8.439)	(4.795)	(7.932)	(5.287)
	3	−0.015***	−0.021***	−0.020***	−0.025***
		(5.392)	(3.954)	(5.495)	(4.492)
	4	−0.012***	−0.016***	−0.018***	−0.019***
		(4.416)	(2.981)	(5.007)	(3.558)
	5	−0.005*	0.005	−0.010***	0.002
		(1.874)	(0.871)	(2.683)	(0.356)
Average wage	2	−0.022***	−0.015***	−0.028***	−0.016***
		(10.981)	(3.809)	(10.600)	(3.976)
	3	−0.029***	−0.026***	−0.040***	−0.028***
		(13.078)	(6.160)	(13.093)	(6.290)
	4	−0.035***	−0.035***	−0.049***	−0.037***
		(14.395)	(7.030)	(14.561)	(7.128)
	5	−0.041***	−0.040***	−0.060***	−0.043***
		(15.193)	(7.747)	(16.049)	(8.009)
CV of wage	2	0.024***	0.012***	0.045***	0.016***
		(12.425)	(3.343)	(17.123)	(4.175)
	3	0.033***	0.018***	0.057***	0.023***
		(14.413)	(4.546)	(18.666)	(5.322)
	4	0.035***	0.016***	0.060***	0.020***
		(13.465)	(3.715)	(17.625)	(4.365)
	5	0.045***	0.029***	0.077***	0.034***
		(15.459)	(5.949)	(20.850)	(6.769)
Sales/employee	2	−0.016***	−0.031***	−0.014***	−0.031***
		(7.316)	(7.218)	(4.887)	(6.902)
	3	−0.020***	−0.039***	−0.018***	−0.039***
		(8.897)	(7.644)	(6.060)	(7.353)
	4	−0.012***	−0.041***	−0.005	−0.040***
		(5.012)	(8.682)	(1.491)	(8.206)
	5	−0.009***	−0.035***	−0.001	−0.034***
		(3.679)	(6.428)	(0.451)	(6.082)
Average tenure	2	−0.047***	−0.026***	−0.057***	−0.028***
		(23.054)	(6.338)	(21.052)	(6.530)
	3	−0.064***	−0.029***	−0.083***	−0.032***
		(27.145)	(6.113)	(25.991)	(6.509)
	4	−0.071***	−0.038***	−0.094***	−0.042***
		(27.550)	(7.568)	(26.481)	(7.889)
	5	−0.068***	−0.033***	−0.094***	−0.037***
		(25.103)	(6.033)	(24.596)	(6.314)
$NET(t-1)$		0.075***	0.051***	0.108***	0.055***
		(34.419)	(8.415)	(38.312)	(8.734)
N		219351	219351	219351	219351
R^2		0.070	0.090		

Note: See Table 1.

variable on the mean of a flow would include the influence of the variable in question on the probability of the flow to be non-zero. In a corner solution model it is these marginal effects, rather than the parameters themselves that should be examined (Dow and Norton, 2003). However, if we use employment weights in estimation, the Tobit estimates are very close to the OLS estimates which directly give

Table 3. Models for churning rate *CF*

		OLS, unweighted	OLS, weighted	Tobit 2, continuous part, unweighted	Tobit 2, continuous part, weighted
Plant size	2	0.056***	0.040***	0.070***	0.021***
		(28.561)	(9.606)	(21.732)	(3.701)
	3	0.074***	0.058***	0.108***	0.040***
		(29.437)	(10.917)	(27.252)	(5.635)
	4	0.094***	0.065***	0.156***	0.053***
		(28.563)	(12.554)	(32.657)	(7.953)
	5	0.102***	0.081***	0.190***	0.074***
		(21.092)	(11.938)	(30.424)	(9.216)
Plant age	2	−0.016***	−0.020***	−0.028***	−0.021***
		(5.692)	(3.726)	(6.232)	(3.656)
	3	−0.004	−0.010*	−0.016***	−0.013**
		(1.551)	(1.701)	(3.472)	(2.047)
	4	−0.000	−0.003	−0.012**	−0.005
		(0.053)	(0.452)	(2.542)	(0.798)
	5	0.009***	0.021***	−0.001	0.018***
		(2.835)	(3.213)	(0.299)	(2.605)
Average wage	2	−0.019***	−0.021***	−0.028***	−0.021***
		(8.829)	(4.759)	(8.065)	(4.346)
	3	−0.029***	−0.039***	−0.042***	−0.037***
		(12.108)	(7.880)	(10.713)	(6.941)
	4	−0.032***	−0.051***	−0.047***	−0.050***
		(12.078)	(8.736)	(10.848)	(7.861)
	5	−0.035***	−0.061***	−0.057***	−0.061***
		(12.027)	(10.382)	(11.742)	(9.360)
CV of wage	2	0.002	0.003	0.005*	0.000
		(1.114)	(0.753)	(1.646)	(0.100)
	3	0.006**	0.002	0.011***	−0.002
		(2.410)	(0.477)	(2.999)	(0.464)
	4	0.008***	0.010**	0.017***	0.005
		(3.256)	(2.091)	(4.162)	(1.004)
	5	0.014***	0.025***	0.033***	0.017***
		(5.096)	(4.266)	(7.688)	(2.714)
Sales/employee	2	−0.003	−0.022***	−0.003	−0.022***
		(1.143)	(4.259)	(0.688)	(3.914)
	3	−0.006**	−0.041***	−0.008**	−0.041***
		(2.546)	(7.623)	(2.034)	(6.855)
	4	0.006**	−0.035***	0.012***	−0.035***
		(2.276)	(5.942)	(3.062)	(5.378)
	5	0.011***	−0.028***	0.019***	−0.028***
		(4.306)	(4.413)	(4.584)	(4.082)
Average tenure	2	−0.060***	−0.034***	−0.087***	−0.035***
		(26.363)	(7.112)	(25.168)	(6.941)
	3	−0.086***	−0.054***	−0.133***	−0.058***
		(33.879)	(10.520)	(32.612)	(10.478)
	4	−0.098***	−0.074***	−0.156***	−0.080***
		(35.987)	(13.441)	(34.395)	(13.158)
	5	−0.100***	−0.079***	−0.171***	−0.087***
		(34.520)	(13.893)	(34.077)	(13.749)
$NET(t-1)$		0.008***	0.013***	0.010***	0.013***
		(3.315)	(3.169)	(2.856)	(3.023)
N		219351	219351	219351	219351
R^2		0.071	0.148		

Note: See Table 1.

marginal effects. Therefore we do not report the Tobit marginal effects separately.

The coefficients of the plant size variables are very significant and show a pattern where small plants have the lowest inflow and churning rates and the highest outflow rates. Especially the churning rate increases with plant size. This implies that in the larger plants high inflow is related not only to high

Table 4. Probit models for *WIF*, *WOF*, and *CF*

		Tobit 2, probit part, ML estimates					
		WIF		WOF		CF	
		Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Plant size	2	0.563***	0.496***	0.245***	0.262***	0.596***	0.624***
		(83.608)	(32.572)	(37.702)	(19.305)	(80.041)	(33.351)
	3	0.856***	0.830***	0.412***	0.499***	0.955***	1.095***
		(98.331)	(41.000)	(49.425)	(28.003)	(100.439)	(45.333)
	4	1.083***	1.054***	0.508***	0.616***	1.261***	1.468***
		(95.841)	(44.517)	(47.772)	(30.688)	(104.312)	(48.955)
	5	1.244***	1.236***	0.555***	0.626***	1.500***	1.806***
		(62.788)	(43.681)	(28.804)	(26.603)	(72.067)	(40.948)
Plant age	2	−0.032***	−0.051**	−0.073***	−0.110***	−0.060***	−0.087***
		(3.298)	(2.286)	(7.758)	(5.212)	(5.645)	(3.717)
	3	0.009	0.022	−0.052***	−0.096***	−0.035***	−0.048*
		(0.976)	(0.859)	(5.365)	(4.563)	(3.218)	(1.874)
	4	0.038***	0.083***	−0.052***	−0.077***	−0.030***	−0.023
		(3.945)	(3.094)	(5.355)	(3.680)	(2.806)	(0.854)
	5	0.105***	0.204***	−0.031***	0.008	−0.014	0.075***
		(10.420)	(7.870)	(3.133)	(0.361)	(1.213)	(2.622)
Avg. Wage	2	−0.026***	−0.054***	−0.069***	−0.059***	−0.052***	−0.078***
		(3.463)	(3.050)	(9.659)	(3.724)	(6.446)	(3.952)
	3	−0.029***	−0.090***	−0.103***	−0.106***	−0.090***	−0.151***
		(3.438)	(4.376)	(12.518)	(6.127)	(9.778)	(6.693)
	4	−0.024**	−0.147***	−0.125***	−0.141***	−0.102***	−0.203***
		(2.547)	(5.951)	(13.891)	(7.129)	(10.060)	(7.659)
	5	−0.006	−0.122***	−0.155***	−0.164***	−0.126***	−0.243***
		(0.544)	(4.894)	(15.461)	(7.893)	(11.153)	(9.258)
CV of wage	2	−0.070***	−0.137***	0.137***	0.068***	0.059***	0.038**
		(10.000)	(6.972)	(19.690)	(4.526)	(7.748)	(2.061)
	3	−0.080***	−0.157***	0.170***	0.100***	0.080***	0.044**
		(9.845)	(6.993)	(21.061)	(6.106)	(9.090)	(2.101)
	4	−0.075***	−0.135***	0.182***	0.090***	0.097***	0.076***
		(8.222)	(5.794)	(20.038)	(5.077)	(9.830)	(3.330)
	5	−0.053***	−0.101***	0.229***	0.145***	0.138***	0.130***
		(5.353)	(4.413)	(23.149)	(7.498)	(13.212)	(5.010)
Sales/empl.	2	0.047***	−0.039*	−0.032***	−0.117***	0.005	−0.080***
		(5.948)	(1.841)	(4.135)	(6.775)	(0.532)	(3.547)
	3	0.048***	−0.095***	−0.043***	−0.148***	−0.007	−0.160***
		(5.856)	(4.227)	(5.380)	(7.295)	(0.812)	(6.816)
	4	0.088***	−0.089***	−0.005	−0.147***	0.046***	−0.130***
		(10.227)	(4.050)	(0.628)	(7.843)	(4.904)	(5.003)
	5	0.132***	−0.038	0.006	−0.126***	0.067***	−0.092***
		(14.452)	(1.644)	(0.692)	(5.766)	(6.796)	(3.315)
Avg. tenure	2	−0.225***	−0.205***	−0.146***	−0.105***	−0.186***	−0.134***
		(30.019)	(10.553)	(20.127)	(6.263)	(22.982)	(6.112)
	3	−0.322***	−0.281***	−0.212***	−0.122***	−0.291***	−0.228***
		(36.902)	(12.320)	(24.877)	(6.332)	(30.617)	(9.653)
	4	−0.397***	−0.378***	−0.244***	−0.160***	−0.349***	−0.315***
		(40.760)	(15.409)	(25.707)	(7.722)	(32.985)	(12.216)
	5	−0.423***	−0.416***	−0.243***	−0.137***	-0.379***	−0.337***
		(40.005)	(15.600)	(23.856)	(6.087)	(32.525)	(12.529)
$NET(t-1)$		−0.350***	−0.284***	0.300***	0.219***	0.055***	0.067***
		(41.020)	(9.643)	(39.303)	(9.177)	(6.749)	(3.607)
N		219351	219351	219351	219351	219351	219351
Share of zeroes		0.41	0.41	0.36	0.36	0.55	0.55

Note: See Table 1.

employment growth, but also to replacement hiring. In the smaller plants the worker flows are mainly related to plant employment changes and there is therefore less churning. The low flow rates in small plants are somewhat surprising, since there is evidence from other studies that e.g. churning is high in small firms (Burgess *et al*., 2000b). Our results may have been influenced by the use of only continuing plants. In earlier work with only manufacturing data (Ilmakunnas and Maliranta, 2000) we found that smaller plants had higher churning rates. It is also possible that plant size picks up differences in the hiring and firing costs, which may be relatively higher for small employers. When we compare weighted and unweighted estimates, the difference in the flow rates across plant size classes becomes smaller, which is what we would expect when weighting by plant size is applied.

The relationship between plant age and the worker inflow is such that group 2 has the lowest flow rate and otherwise inflow increases when plant age drops (group 5 is the youngest plants). As to outflow and churning, group 5 has the highest flow rates, and groups 2–4 the lowest. High churning in young plants may be related to the process of finding good 'matches' between employers and employees. When plants become older the flow rates decline. From the differences of the coefficients of the plant age group variables in the WIF and WOF equations (weighted OLS estimates) we can directly infer the impact of plant age on net employment change NET. The difference in the coefficients is positive and increases when we move towards group 5 which includes the youngest plants. This implies a negative connection between plant growth and plant age, which is consistent with results in studies of firm growth.

Low wage plants have both high inflow and outflow rates, as expected when quits depend on wage. After weighting by employment, the impact of wage on *WIF* becomes stronger, whereas in case of *WOF* weighting has less impact. Also churning falls with average wage, as predicted by theory and the impact becomes even stronger when weighting is used in estimation. Note that the categorical wage variable essentially measures relative wage within the industry. It can be conjectured that plants with relatively low pay both face higher quit rates[17] and adverse demand conditions which lead to higher layoff rates. High-wage plants, on the other hand, have been able to limit the turnover with their pay policy. Since the coefficients of the wage group variables are higher in absolute value in the *WOF* equation than in the *WIF* equation, we get a negative connection between employment change *NET* and wage which is consistent with a standard downward sloping labour demand curve.

Plants with high wage variability (measured by CV) have lower inflow rates than the reference group 1, but there is not much difference between groups 2 to 4. Outflow increases with wage variability and also churning is highest in the high wage variability group. Plants with a more homogeneous workforce in terms of pay have lower flow rates. Note that both high average wages and low within-plant wage variation produce low churning rates. This is consistent with the theoretical arguments that high wage reduces worker turnover, but wage differences lead to raiding of employees by competitors or to quitting of those workers that have a preference for equality. Another interpretation is that wage variation reduces turnover in good matches more than it increases turnover in poor matches. It is also possible that high within-plant wage variability reflects a high share of part-time workers who may be more prone to switch jobs. Comparison of weighted and unweighted estimates shows that they are fairly close to each other; only in case of *WIF* does weighting seem to drop the coefficients.

In the case of productivity (sales/employee) weighting in estimation makes a big difference: unweighted estimation yields negative coefficients for the productivity groups in the *WIF* equation, whereas in weighted estimation they are positive. Also in the case of churning weighted estimation seems to make a difference in the estimates. Using the weighted estimates we conclude that low productivity plants have the highest inflow rates. Inflow is lowest in groups 3 and 4. Also the outflow rate drops with productivity, and a comparison of the coefficients in the *WIF* and *WOF* equations shows that net employment change has been higher in the high productivity plants. They have a lower hiring rate, but also a much lower separation rate than the low productivity plants. Finally, churning drops with plant productivity, being lowest in groups 3 and 4. Since we have controlled the wage, this effect is not related to high turnover caused by lower pay in low productivity plants.

Low average tenure is associated with higher flow rates. High tenure plants have especially low hiring

[17] This is also evidenced by the fact that if our proxy for quits, *WOF–WOFU* is regressed on the same variables, the coefficients of the wage groups decline when we go from group 2 to group 5 (results not reported in the tables).

and churning rates, but differences in the outflow rates are smaller. All of these effects drop in absolute value when weighted estimation is used. Since the coefficients are lower (higher in absolute value) in the *WIF* equation than in the *WOF* equation, we can conclude that net employment growth has been weakest in the high tenure plants. It is difficult to judge what the roles of state dependence and heterogeneity are in the impact of tenure on turnover. However, since we control for various average worker characteristics, and also for wage variation between workers, it is likely that the negative impact of tenure on outflow and replacement hiring can be attributed to true state dependence in quit rates.

Finally, the lagged net employment change has a highly significant negative impact on the hiring rate and a positive impact on the separation rate. There is an error correction mechanism: plants that grow fast and hire too many new workers may have to adjust their workforce downwards in the following year. The adjustment happens partly through more separations and partly through less hiring. Part of the increase in outflow reflects broken matches that are replaced, as evidenced by the positive coefficient of $NET(-1)$ in the churning equation. The adjustment process can also be seen as a negative impact of the lagged employment change to present employment change. The coefficient of $NET(t-1)$ is -0.060 in the *WIF* equation (OLS, weighted) and 0.051 in the *WOF* equation, and the difference in the coefficients is -0.009. Note that these results are not inconsistent with an increase in the aggregate worker outflow rate in recession. A negative employment change may increase outflow already in the same period (by definition, $WOF = WIF - NET$), whereas the results here deal with influences over time.

We briefly comment on the impact of the variables that are not shown in the tables. The year dummy variables show clearly the time series pattern of the worker flows during the recovery period when plant and worker characteristics are controlled. The worker inflow rates continued to drop after the deepest recession year 1991 and did not start to increase until 1994. A similar development happened in the churning rates. The outflow rates, on the other hand, systematically decreased from 1991 onwards.

Plants that are foreign owned have somewhat lower churning rates than domestically owned plants. They also have lower outflow rates, but there is no significant difference in the inflow rates. This implies that foreign-owned plants have had higher growth rates. Change of ownership from domestic to foreign, however, increases the outflow rate. It is likely that this kind of ownership changes lead to a restructuring of the workforce.

The churning rate and worker inflow rate are clearly negatively correlated with average worker age. Also the outflow rate drops with average employee age, but much less than the other flow rates. Churning and inflow have U-shaped relationships with the educational level of employees; these rates are highest in groups 1 (reference group) and 5. Excess turnover is high when the employees have more job opportunities given by high education, whereas the high churning rate in plants with low education may reflect more uncertainties in the matching process when education is not used as a signal of high productivity. Education does not have a significant impact on the outflow rate in weighted estimations. The share of women has a negative impact on the hiring rate, but a positive effect on outflow and churning. This reflects more extensive career interruptions in plants with a high share of female workers. Home ownership is connected with low churning, inflow, and outflow. The results give indirect support to the hypothesis of the influence of housing on the labour market. Workers who own their own house may be less willing to switch jobs. Finally, the regional unemployment rate has a negative effect on the flow rates, but in weighted estimation this effect turns positive and it is insignificant.

Table 4 reports the results on the probit part of the Tobit 2 models. The correlation between the two parts of the model was high in all cases; the estimated correlation coefficients were over 0.9 and very significant. We discuss the results mainly to the extent that the signs of the coefficients differ from those in the continuous part. Plant size has a strong effect on the flows. Especially in the cases of *WIF* and *CF* the ratio of coefficients of group 5 and group 2 is higher than in the continuous part. In case of *WOF*, plant size has a positive effect on the probability of having a nonzero flow rate, but a negative effect on the magnitude of the flow in the continuous part of the model. In contrast, small plants have both a clearly lower probability of positive inflow and slightly lower inflow rates. These results may reflect size-related lumpy adjustment costs and asymmetries in hiring and firing costs.

The categorical variables describing plant age, average wage, wage variability, productivity, and average tenure have the same signs in both parts of the model. In case of productivity, the signs of the coefficients in the inflow and churning models change when weighted estimation is used. Again, this is similar to the result obtained for the continuous part. The rest of the control variables have qualitatively the same kind of impact both on the probability of positive flows and the magnitude of the flow rates.

VII. Conclusions

We have examined worker turnover and its determinants using plant-level data that combines information on both plants (employers) and their employees. We have estimated models where the churning, worker inflow, and worker outflow rates are explained with various plant and worker characteristics, and compared different estimation methods.

Our main findings are the following. High-wage plants have low turnover, whereas plants with large within-plant variation in wages have high turnover. Average tenure of employees has a negative impact on turnover. High plant employment growth increases churning and separation but reduces hiring in the next year. We have also controlled various other plant and average employee characteristics like average age and education, shares of women and homeowners, foreign ownership, ownership changes, and regional unemployment.

It turns out that it is useful to let the variables have a different impact on the probability of having non-zero flow rates and on the magnitude of the flow rate. For example, the results show that the probabilities of observing non-zero churning, inflow, and outflow rates increase with plant size. On the other hand, the magnitudes of the non-zero churning and inflow rates depend positively on size, but the magnitude of outflow rate negatively. For the other variables, there is less difference in the coefficients between the two parts of the model.

It is also useful to weight the observations by plant size since then the zero observations that are frequent in small plants have less weight. As far as the continuous part of the model is concerned, using weighted OLS gives practically the same results as maximum likelihood estimation of the type 2 Tobit model.

In future work the analysis could be extended to a choice between a larger number of flow regimes. The plants can be classified to discrete locations in the triangle of Fig. 1, and the determinants of plant location can then be analysed using, for example, multinomial logit models. Another interesting topic would be to compare modelling of flow rates, as in this paper, to modelling of flows. Since the numbers of persons hired or separated are discrete numbers, count data models should be used. The high concentration of zeroes in the distribution of flows also justifies the use of zero-inflated count models.

Acknowledgements

This research has been supported by the Academy of Finland (project 50950). When this research was carried out, Mika Maliranta was working for Statistics Finland. Earlier versions of this paper have been presented at EALE Conference, Jyväskylä, and Conference on Microeconomic Analyses of Labour Reallocation at Upjohn Institute of Employment Research, Kalamazoo, Michigan. The data set used in the paper can be accessed in the Research Laboratory of the Business Structures unit of Statistics Finland.

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Appendix: Data Sources

The Employment Statistics (ES) data base includes information on the labour market status of individuals and their background characteristics from different administrative registers. It covers effectively the whole population of Finland. There are over 2 million employees in this register. In the business sector there are more than 1.1 million employees in about 100,000 plants. The Business Register (BR) data base covers registered employers and enterprises subject to VAT and their plants. There are over 200 000 business sector plants in the register.

For each person in ES a plant appearing in BR is determined as the primary employer during the last week of each year. This is the source of information for employment, inflow and outflow of workers. ES is also used for calculating the characteristics of the workforce for each plant, like average age, tenure, education, and wages (earnings). BR is the source of information on plant age, industry classification, and productivity (sales per employee).

We discuss the linking of the registers and the properties of the linked data in more detail in Ilmakunnas *et al*. (2001). Due to incompleteness in the matching of workers and plants and missing observations on some of the variables, the number of observations in the estimations is smaller than the number of plants in the registers. In order to have consistent job and worker flow series we have dropped the persons that are not linked to a plant that appears in BR. We have reason to believe that in the first years of the data the flow rates are too high, most likely because of deficiencies in the definitions of the employment status of the workers (Ilmakunnas and Maliranta, 2003). Therefore we use data from the period 1991–1997 in the estimations.

We define the business sector to include the following industries: mining and quarrying (C), manufacturing (D), electricity, gas and water supply (E), construction (F), wholesale and retail trade (G), hotels and restaurants (H), transport, storage, and communications (I), financial intermediation (J), and real estate, renting, and business activities (K). Hence, we exclude agriculture, hunting, and forestry (A), fishing (B), public administration and defense, and compulsory social security (L), education (M), health and social work (N), other community, social and personal service activities (O), international organizations (Q), and industry unknown (X).