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WORKER INFLOW, OUTFLOW, AND CHURNING***

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ABSTRACT: Linked employer-employee data from the Finnish business sector is used in an analysis of worker turnover. The data is an unbalanced panel with over 219 000 observations in the years 1991-97. The churning (excess worker turnover), worker inflow (hiring), and worker outflow (separation) rates are explained by various plant and employee characteristics in type 2 Tobit models where the explanatory variables can have a different effect on the probability of the flow rates to be non-zero and on the magnitude of the flow rate when it is positive. Most of the characteristics are defined as 5-group categorical variables defined for each industry separately in each year. We compare the Tobit results to OLS estimates, and also use weighting by plant employment. It turns out that weighted OLS results are fairly close to Tobit results.

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 negatively. 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 also control various other plant and average employee characteristics like average age and education, shares of women and homeowners, foreign ownership, ownership changes, and regional unemployment.

Keywords: worker turnover, churning, employer-employee data

JEL code: J23, J41, J63

EI-TEKNINEN TIIVISTELMÄ: Työntekijävirtoja on tutkittu yhdistettyjen työntekijä-työnantaja -aineistojen avulla. Tutkimuksessa käytetään toimipaikkatason paneeli-aineistoa, jossa on yli 219 000 havaintoa vuosilta 1991–97. Selittävinä muuttujina ovat työntekijöiden rekrytoinnit (sisäänvirtaus), työsuhteiden päättyminen (ulosvirtaus) sekä ns. "kirnuaminen" tai ylimääräinen vaihtuvuus. Kirnuamisella tarkoitetaan sellaista työntekijöiden samanaikaista (saman vuoden aikana tapahtuvaa) sisään- ja ulosvirtausta, joka ei liity toimipaikan työntekijämäärän kasvuun tai supistumiseen. Nämä työntekijävirrat on ilmaistu asteina suhteuttamalla ne toimipaikan työntekijämäärään. Selittävinä tekijöinä on käytetty erilaisia toimipaikka- ja työntekijäominaisuuksia.

Estimoinnit on tehty käyttämällä tilastollisia malleja (ns. tobit 2 malli), joissa selittävillä muuttujilla voi olla erilainen vaikutus todennäköisyyteen, että virta-aste on nolla sekä virta-asteen suuruuteen siinä tapauksessa, että virta-aste on aidosti positiivinen. Useimmat selittävät toimipaikan ja sen työntekijöiden ominaispiirteet on mitattu 5-ryhmäisellä luokittelumuuttujajoukolla. Ryhmät on määritelty erikseen jokaiselle toimialalle jokaisena vuotena. Tobit-malleilla saatuja tuloksia verrataan tavallisella regressioanalyysilla (OLS) saataviin tuloksiin. Lisäksi tarkastellaan sitä, kuinka tulokset muuttuvat, kun toimipaikkahavaintoja painotetaan niiden henkilömäärällä. Osoittautuu, että työtekijäpainoja käytettäessä OLS- ja Tobit-tulokset ovat hyvin samanlaisia.

Toimipaikkakoon kasvaessa lisääntyy todennäköisyys, että toimipaikalla on tapahtunut vuoden aikana edes jonkin verran työntekijöiden sisäänvirtausta, ulosvirtausta ja kirnuamista. Kun virta-aste on aidosti positiivinen, toimipaikan koko vaikuttaa positiivisesti sisäänvirtaus- ja kirnuamisasteen suuruuteen, mutta negatiivisesti ulosvirta-asteeseen. Korkean palkkatason toimipaikoilla on pieni työntekijöiden vaihtuvuus. Kun toimipaikan sisäinen palkkahajonta on suuri, vaihtuvuus on kuitenkin suuri. Yrityskohtaisella työkokemuksella on negatiivinen vaikutus vaihtuvuuteen. Toimipaikan työllisyyden lisäys kasvattaa seuraavan vuoden kirnuamista ja ulosvirtausta sekä vähentää rekrytointia. Tutkimuksessa on kontrolloitu erilaisia muita toimipaikka- ja työntekijäominaisuuksia, kuten toimipaikan ikä, sen työvoiman keski-ikä ja koulutustaso, sukupuolijakauma, omistusasunnon haltijoiden osuus, ulkomaalaisomistus, omistuksen muutos sekä alueellinen työttömyysaste.

1. 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 macro perspective, 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 1980's there has been much emphasis also on the analysis of job turnover[2], 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 labor market[3]. In this case, one of the issues has been the extent and causes of 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 (LEE) data from Finland 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

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1 In economics e.g. Parsons (1977, 1986) and Farber (1999) survey the turnover literature from different angles. For the human resource management literature, see e.g. Cotton and Tutle (1986) and Griffeth, Hom, and Gaertner (2000).

2 See Davis, Haltiwanger, and Schuh (1996) and Davis and Haltiwanger (1999).

3 See e.g. Abowd, Corbel, and Kramarz (1999), Hamermesh, Hassink, and van Ours (1996), Burgess, Lane, and Stevens (2000a), Albæk and Sørensen (1998).

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[4]. Finally, we compare different estimation approaches, OLS vs. Tobit type models, and weighted vs. 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 work force. Secondly, cyclical changes in the Finnish economy have been very strong in the 1990's[5]. The end of the 1980's was a period of rapid growth and overheating of the Finnish economy. In the beginning of the 1990's this was followed by a period of very deep recession. The unemployment rate rose rapidly in a few years from 3 to 17 percent, 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 2 and a review of the relevant theories on worker turnover in Section 3. We discuss the data and the econometric approach in Section 4 and examine empirically the influence of various variables on the worker flows in Section 5. Section 6 concludes the paper.

2. 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 aver-

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4 We analyze the cyclical behavior of the gross job and worker flows at the aggregate level and in main industries in a separate paper (Ilmakunnas and Maliranta, 2003).

5 The Finnish recession is described e.g. by Honkapohja and Koskela (1999).

age employment in years t and $t-1$, we obtain the worker inflow rate or hiring rate $WIF_t = \Sigma_i H_{it}/(\Sigma_i(E_{it}+E_{i,t-1})/2)$, where H_{it} denotes hiring and E_{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 $WOF_t = \Sigma_i S_{it}/(\Sigma_i(E_{it}+E_{i,t-1})/2)$, 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 leave a detailed analysis of these unemployment related flows to future work.

Job flows are defined following Davis et al. (1996). 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, $JC_t = \Sigma_i \Delta E_{it}^{+}/(\Sigma_i(E_{it}+E_{i,t-1})/2)$, 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, $JD_t = \Sigma_i|\Delta E_{it}^{-}|/(\Sigma_i(E_{it}+E_{i,t-1})/2)$, 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 "excessive". The difference of the worker turnover and job turnover rates is the churning flow rate, $CF_t = WF_t - JR_t$ (Burgess, Lane, and Stevens, 2000a)[6], 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".

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

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 Figure 1[7]. (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 ≥ |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 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.

[7] The idea of this triangle is adopted from Burgess, Lane, and Stevens (2000a). In Ilmakunnas and Maliranta (2000) we present the distribution of Finnish manufacturing plants in the triangle.

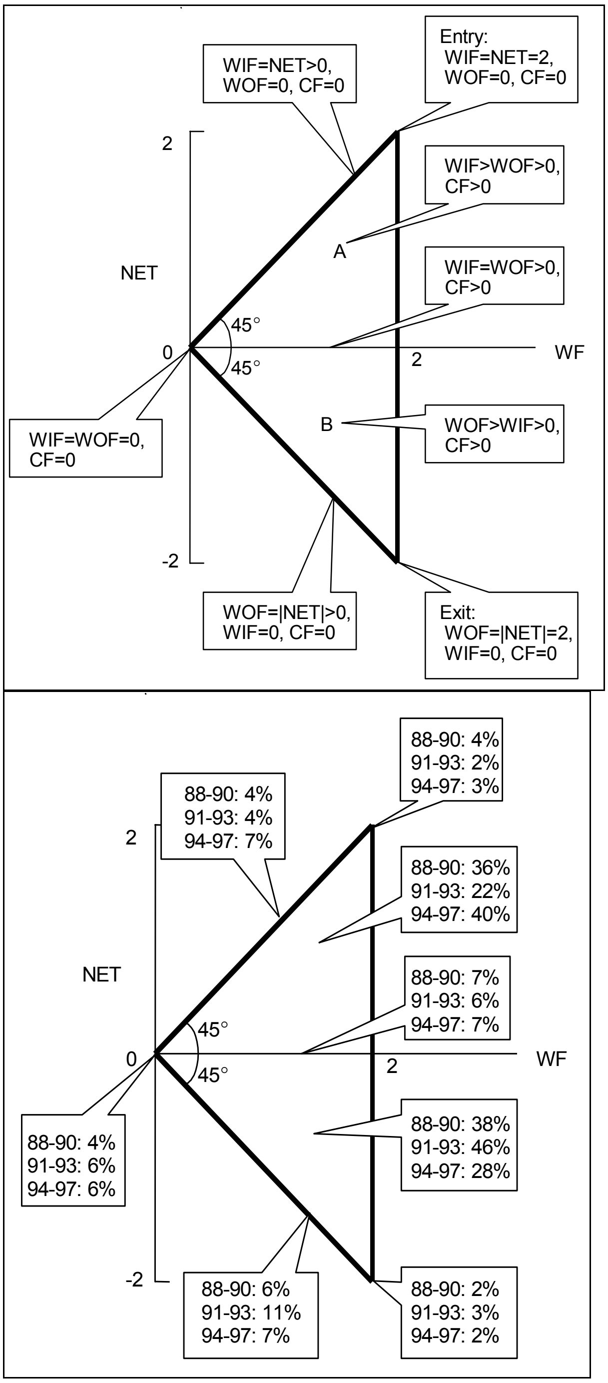

Figure 1: The flow regimes at the plant level (left) and employment shares of the flow regimes in 1988-90, 1991-93 and 1994-97 (right)

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[8] 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 Figure 1 shows the employment shares of the plants in the Finnish business sector in the regimes in three time periods. The years 1988-90 were a boom period, the period 1991-93 was the deepest recession, and the years 1994-97 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[9]. 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 work force in the business sector during the recession and 6-7 % in the other periods. The plants that have declined, but still have

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8 Already 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.

9 For example in manufacturing, the entering 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 e.g. by mergers.

hired some new workers have experienced big changes in their employment share. They had 38 % of employment in 1988-90, but 46 % during the recession and 28 % in recovery. The plants that have not grown and have had no turnover in their work force, 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 % percent of the business sector employment. The employment share of growing plants that have had some separations has varied widely. It decreased from 36 % in 1988-90 to 22 % in 1991-93, and increased again to 40 % in 1994-97. 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 fourths of the business sector employees have been in plants that have had some churning. It is clearly a phenomenon that deserves attention.

3. Theories of worker turnover and their implications for empirical work

When data on individuals are used for studying worker turnover, the emphasis is usually on the length of tenure or probability of separation. With other types of data, typically either the quit rate or separation rate is the variable to be explained. Recent research has examined simultaneous hiring and separation and the determinants of excess turnover at the plant level. We review here some theories and empirical approaches that are relevant for plant-level analysis.

A negative relationship between wage and turnover arises in many different models. In many matching models the quality of the match is only revealed after the match has been created (e.g. Jovanovic, 1979a). Workers stay in matches with high productivity and wage, whereas low wage workers quit. As a result, wage is negatively correlated with the separation rate. In on-the-job search models a quit is the workers decision based on the probability of job offers and the distribution of wages (e.g. Burdett, 1978, Jovanovic, 1979b). Also these models imply a negative relationship between wage and separations. The same qualitative relationship between wage and separation is obtained even when search aspects are combined to the matching model (Mortensen, 1988).

Since quits lead to a need for rehiring, these models also imply that churning is negatively related to wage. From the firm's point of view, the success in hiring depends on the number of job seekers and the probability that the wage offer is high enough.

In many models quits account for total separations. From the theoretical point of view, their distinction 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).

Efficiency wage theories (e.g. Salop, 1979) also posit dependence of the quit rate on wage. Quits lead to hiring of new workers and this turnover involves hiring and training costs. Employers try to reduce the turnover with their wage policy. Some efficiency wage theories are based on the view that higher wage attracts better quality applicants and lessens shirking and thereby decreases layoffs and replacement hiring.

These models also have empirical implications on the relationships of tenure and turnover (see e.g. Topel and Ward, 1992). 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 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).

In a plant-level study the implication of the above models is that the outflow rate of workers should be negatively related to average plant wage, relative to a general or industry average wage. Because outflow through quits causes replacement hiring, also the churning rate should be negatively related to these variables. 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 work force characteristics. A remaining problem is, however, that turnover, wage, and tenure are likely to be jointly determined.

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 researcher 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 (e.g., Leonard, Mulkay, and van Audenrode, 1999, and 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. E.g. Powell, Montgomery, and Cosgrove (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. The relationship between wage variation and turnover may, however, 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 (see e.g. Telly, French, and Scott, 1971, Galizzi, 2001). In sum, the impact of wage dispersion on turnover is unclear.

There is plenty of empirical evidence that quit rates tend to be strongly procyclical, whereas layoffs are less strongly countercyclical, making total separations procyclical (e.g. Akerlof, Rose, and Yellen, 1988, Parsons, 1977). The matching and search models are not always concerned with the cyclical behavior of worker turnover, since separation is followed by a new hire. The cyclical situation can, however, be taken into account through the probability of finding a new job, which varies over the business cycle. Hence, the vacancy rate and unemployment rate are often used as determinants of quits, especially in time series studies. In models where demand is allowed to change and wage changes are constrained because of contracts, demand shifts can cause "forced" quits during upturns when wage does not increase and layoffs in downturns when wage does not decrease (Hall and Lazear, 1984).

In studies of worker mobility where the emphasis is on displacement, the separations are involuntary. In fact, much of the literature on job creation and destruction is at least implicitly based on involuntary separation through the exit or downsizing of firms. One reason for turnover is therefore the employment change of the firm. Demand influences are directly included in adjustment cost models of labor demand. Given fluctuations in demand and wage, and a quit rate, the firms adjust the size of the labor force through hiring or firing (Hamermesh, 1993). Firms would not hire and fire at the same time unless the work force is heterogeneous. The actual amount of adjustment depends, among other things, on the hiring and firing costs. Also the shape of the adjustment cost schedule matters. Lumpiness in the costs may cause the firms not to react to e.g. small changes in demand. Differences between plants in their hiring rates therefore also reflect the heterogeneity of plants in the growth of demand. These demand differences may be attributable to differences in industry cycles, and within industries to productivity differences. Demand may also have more indirect influences on turnover. In growing firms the need to hire lots of new workers may lead to a deterioration of the quality of the matches. This can show up later as increasing separations and excessive turnover (Burgess, Lane, and Stevens, 2000a,b). Also in declining firms, layoffs may give rise to more quits if workers see their future prospect bleak. Therefore, also job destruction may lead to excessive turnover.

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). In this case the nature of the jobs actually changes, but this cannot be observed with the kind of data sets that are typically used. There has been discussion on the consequences of ownership changes on employment growth (see e.g. McGuckin and Nguyen, 2001). However, changes from e.g. foreign to domestic ownership can still have an impact on worker turnover even when plant employment does not change. Some workers may voluntarily switch jobs after a change in ownership.

There is evidence that plant age and size affect excess turnover (Lane, Isaac, and Stevens, 1996, Burgess, Lane, and Stevens, 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 one could 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. Firm size can also pick up differences in the hiring and firing costs.

So far we have concentrated on the characteristics of the firms that affect the amount of turnover. However, also the composition of the work force is likely to have an influence on the actual process of turnover. The work force characteristics can be included in the models if it is assumed that they influence the parameters of the theoretical models, e.g. job switching costs, in a certain way. 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).

There are potential negative effects of home ownership on the mobility of labor (see 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. Naturally, there can be such a selection mechanism that workers who dislike job switches tend to buy their own home. Also the age of the work force 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 work force may thus be an important explanatory variable.

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 work force. 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 work force. 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. This also raises mobility costs and lowers quits (Neal, 1998).

It should be noted that the composition of the work force 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. This kind of simultaneity of turnover with the work force characteristics may be a problem in empirical work.

4. 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 1988-90 is excluded because it is somewhat less reliable (see Ilmakunnas and Maliranta, 2002, 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. 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 labor market. We could use it as an approximation of the quit rate[10]. We do not present results on this measure of quits, but briefly comment on some estimations made. 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.

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[11]. In this way we avoid problems with the definition of entry and exit. This leaves so few 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 percent of values are zeros, and for WIF and WOF, the shares are somewhat lower, 41 and 36 percent, 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,

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[10] Sometimes when direct information on quits is not available, separations from plants with large percentage employment declines has been treated as layoffs and the other separations as quits (e.g. Jacobson, LaLonde, and Sullivan, 1993, Galizzi and Lang, 1998).

[11] 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.

which is common in plant-level data.[12] 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 e.g. 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 (or Heckman's selection 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. The zeros are not due to censoring. Rather, they are genuine corner solutions, since because of lumpy adjustment costs it may be optimal for the plants to have zero hiring or separation rates. The model is estimated using maximum likelihood including all variables both in the probit and the continuous part. We rely on nonlinearity for indentification 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.

One problem with the use of Tobit type nonlinear models is that the fitted values of WIF and WOF from the continuous parts of the models do not necessarily satisfy the

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[12] 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 (e.g. Greene, 2003, pp. 687-8). Whe 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)).

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, p. 525).

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 plant 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 Figure 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 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 percent. 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.

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 analyze 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).

5. 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.

		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		

Note: Reference group: group 1. 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 1. Models for worker inflow rate WIF

		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.

Table 2. Models for separation rate WOF

		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.

Table 3. Models for churning rate CF

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. In the Tobit model the estimated coefficients that are reported in the tables are not directly the marginal impacts of the variables. The marginal effects of the variables on the means of the flows, conditional on the flows being non-zero, would be the coefficients multiplied by an adjustment factor which is between zero and one.

When evaluated at e.g. the means of the variables, the adjustment factor would be the same for all coefficients. Therefore, e.g. the ratio of the coefficients of groups 5 and 2 for a categorical variable gives the relative impacts of these variables on the conditional mean of a flow. The marginal impacts of the variables on the overall means of the flow rates (including zeros) are roughly the coefficients multiplied by the share of non-zero observations. However, if we use employment weights in estimation, the Tobit estimates are likely to be close to the marginal effects. (Weighted share of zeros becomes closer to zero.) We report robust t-values that also account for correlation of errors between clusters (observations for the same plant).

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 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 (e.g. Burgess, Lane, and Stevens, 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. 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. When OLS and Tobit results are compared, weighting makes the results fairly close to each other, although the OLS estimates are still somewhat lower for WIF, and higher (in absolute value) in case of WOF and CF.

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 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. This is consistent with results in studies of firm growth (see Sutton, 1997).

Low wage plants have both high inflow and outflow rates. 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 (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) 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 labor demand curve.

Interestingly, weighted OLS and weighted Tobit give practically the same result which shows that weighting has indeed made the problem of excessive zeros 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.

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 work force in terms of pay have lower flow rates. Note that especially the combination of high average wages with low within-plant wage variation produces 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. 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 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 natural that in plants that grow faster, simultaneous inflow and outflow of workers results in high churning rates and lower average tenure. It is more 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.

		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 zeros		0.41	0.41	0.36	0.36	0.55	0.55

Note: See Table 1

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

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 work force 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 changes lead to a restructuring of the work force.

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 labor 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 estimations these effects turn positive and are mostly 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. (These ratios do not depend on the adjustment factors that would be needed to obtain the marginal effects.) In case of WOF, plant size has a positive effect on the probability of having a non-zero 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.

6. 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. 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 negatively. 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 Figure 1, and the determinants of plant location can then be analyzed using e.g. multinomial logit models. Another interesting topic would be to compare modeling of flow rates, as in this paper, to modeling of flows. Since the numbers of persons hired or separated are discrete numbers, count data models should be used. The high concentration of zeros in the distribution of flows also justifies the use of zero-inflated count models.

Appendix: Data sources

The **Employment Statistics** (ES) data base includes information on the labor 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 work force 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, Maliranta, and Vainiomäki (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 (see Ilmakunnas and Maliranta, 2002, 2003). Therefore we use data from the period 1991-97 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).

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